BRITISH MUSEUM (NATURAL HISTORY).

BRITISH ANTARCTIC ("TERRA NOVA") EXPEDITION, 1910.

NATURAL HISTORY REPORTS.

ZOOLOGY. VOL. IV.

ECHINODERMA.
PROTOCHORDATA.
BIRDS.

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ECHINODERMA.

PART I.—ACTINOGONIDIATA.

BY

F. JEFFREY BELL, M.A.

WITH ONE PLATE.

LONDON:

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM.

British Museum (Natural History).

This is No 3 *of* 25 *copies of "Terra Nova" Echinoderma, Vol. IV., Part I., printed on Special paper.*

ECHINODERMA.

PART I.—ACTINOGONIDIATA.

BY F. JEFFREY BELL, M.A.,

Emeritus Professor and Fellow of King's College, University of London;
Assistant in the Department of Zoology, British Museum (Natural History).

Descriptions of Species—

A. ANTARCTIC.

LIST OF STATIONS.

Stations.	Locality.	Depth.
194	Off Oates Land, 69° 43′ S., 163° 24′ E.	180–200 fathoms.
220	Off Cape Adare, mouth of Robertson's Bay	45–50 fathoms.
294	Ross Sea, 74° 25′ S., 179° 3′ E.	158 fathoms.
295	„ „ 73° 51′ S., 172° 57′ E.	190 fathoms.
314	5 miles N. of Inaccessible Island, McMurdo Sound	222–241 fathoms.
316	Off Glacier Tongue, about 8 miles N. of Hut Point, McMurdo Sound	190–250 fathoms.
331	Off Cape Bird Peninsula, entrance to McMurdo Sound	250 fathoms.
338	Ross Sea, 77° 13′ S., 164° 18′ E.	207 fathoms.
339	„ „ 77° 5′ S., 164° 17′ E.	140 fathoms.
340	„ „ 76° 56′ S., 164° 12′ E.	160 fathoms.
341	Off Cape Bird Peninsula, entrance to McMurdo Sound	80 metres.
348	Off Barne Glacier, McMurdo Sound	200 fathoms.
355	Ross Sea, 77° 46′ S., 166° 8′ E.	300 fathoms.
356	Off Granite Harbour, entrance to McMurdo Sound	50 fathoms.

As I have already made two Reports on Echinoderms collected in the area visited by the "Terra Nova" (see "Report on the Collections of Natural History made in the Antarctic Regions during the Voyage of the 'Southern Cross,'" London, 1902, pp. 214–220, which I shall refer to as Bell (1), and Vol. IV of the "Natural History" of the National Antarctic ("Discovery") Expedition, 1901–1904, London, 1908,

pp. 1–16, which I shall refer to as Bell (2)), there is no need to give in detail those references to other writers which have already been made.

As several species come from many stations—*Cycethra verrucosa*, for example, having been found at Stations 194, 220, 294, 316, 331, 338, 340, 355, and 356—and as these stations differ very little from one another except in their numbers, I do not propose to burden the text, which I hope to keep as concise as possible, with stating these numbers. Much more do I wish to emphasise a very important fact.

The collection of specimens—in all nearly 500 have been registered, and some 200 put aside for exchange—is very large, although the number of species is comparatively small, but every individual specimen had to be closely scrutinised, for the variation, which I thought I was prepared for by previous experience, was quite beyond my expectation. We are, therefore, brought face to face with an altogether unexpected phenomenon, which in the plainest and most concrete form may be thus stated:— In the area dredged by the "Southern Cross," the "Discovery," and the "Terra Nova," where the conditions of depth and temperature are practically uniform, there is extraordinary variety in the characters of most of the Echinoderms there collected.

CRINOIDEA.

1. *Promachocrinus kerguelensis*, P. H. Carp.

Promachocrinus kerguelensis, P. H. Carp., Bell (2), p. 3.

This species is obviously very widely distributed in the Benthos of the area with which we are dealing; from the fact that a single specimen only was taken by the "Challenger" it was supposed to be rare, but the "Terra Nova" collections show that this view is quite a mistake.

2. *Antedon antarctica*, P. H. Carp.

Antedon antarctica, P. H. Carp., Bell (2), p. 4.

Among the examples of this now well-known form one was found to have six rays.

Stations 194, 295.

3. *Antedon adriani*, Bell.

Antedon adriani, Bell (2), p. 4.

I have not noted any points which I think it necessary to add to the diagnosis I have already published of this species.

I may be allowed to call to mind that this species got its name from the fact that I wished to associate it with the heroic Dr. Wilson, and, having already named a species *A. wilsoni*, I was called on to select one of his Christian names.

Stations 194, 314, 348.

ECHINOIDEA.

4. *Notocidaris mortenseni*, Koehler.

Goniocidaris mortenseni, Koehler, Bull. Ac. Belg. XXXII (1890), p. 816.
Notocidaris mortenseni, Mortensen, Deutsch. Süd. Pol. Exp. XI (1909), p. 18.

Station 294, and south of Balleny Island (69° 43′ S., 163° 24′ E.).

5. *Ctenocidaris perrieri*, Koehler.

Ctenocidaris perrieri, Koehler, 2e Exp. Antarct. Franç. (1912), p. 150.

S. of Balleny Island.

6. *Echinus margaritaceus*, Lamk.

Echinus margaritaceus, Lamk., Bell (1), p. 219.

Stations 220, 338, 339, 340, 355.

7. *Abatus shackletoni*, Koehler.

Abatus shackletoni, Koehler, Brit. Antarct. Exp. 1907–9, Vol. II (1911), p. 51.

One specimen only, from Station 339.

8. *Pseudabatus nimrodi*, Koehler.

Pseudabatus nimrodi, Koehler, id., tom. cit., p. 60.

Stations 294, 339, 355.

This and the preceding species have been so fully described by my learned friend that it appears quite unnecessary for me to add anything to what he has said in such full detail. They are both new to the collection.

ASTEROIDEA.

9. *Asterias longstaffi*, Bell.

Asterias longstaffi, Bell (2), p. 7.

Station 356.

10. *Asterias antarctica*, Lütk.

Asterias antarctica, Bell (1), p. 215.

Stations 294, 295, 331, 338, 339, 340.

11. *Asterias pedicellaris*, Koehler.

Asterias pedicellaris, Koehler, Zool. Anz. XXXII (1907), p. 145.

Stations 339, 340.

12. *Asterias brandti*, Bell.

Asterias brandti, Bell (2), p. 7.

Station 339.

13. *Heuresaster hodgsoni*, Bell.

Heuresaster hodgsoni, Bell (2), p. 8.

Stations 316, 338, 340, 356.

This species is rather more common than I was led to suppose by the "Discovery" collection. A form which I think must be a young stage of this species was taken at Station 339.

14. *Cycethra verrucosa*, Philippi. (Pl. I, figs. 1–6.)

Cycethra verrucosa, Philippi, Bell (1), p. 215; id. (2), p. 10.

If a mystic wanted a type of human life he might well take this species, so astounding are its variations and its modifications, some of which are shown in Plate I. Here, again, we have a warning as to coming to conclusions as to the rarity of species; described many years ago by Philippi from a single specimen, of which a good many years later I also got a single example, it is now known to be exceedingly common and very widely spread.

Numerous Antarctic stations (*see* p. 2.).

In Plate I are given six photographs of *Cycethra verrucosa* to show the variations in form, proportion, and ornamentation. Further light will be found in Prof. Perrier's report on the Cape Horn specimens. Sladen's three sets of two figures each are (i) of natural size, (ii) magnified $1\frac{1}{2}$ diameter, and (iii) magnified 2 diameters, and are, therefore, almost useless for purposes of comparison, though admirable for the establishment of distinct species.

15. *Solaster lorioli*, Koehler.

Solaster lorioli, Koehler, Zool. Anz. XXXII (1907), p. 144.

Numerous Antarctic stations.

16. *Solaster octoradiatus*, Ludwig.

Solaster octoradiatus, Ludwig, Bell (2), p. 11.

This species was only taken from south of Balleny Island.

17. *Cryaster antarcticus*, Koehler.

Cryaster antarcticus, Koehler, Exp. Antarct. Franç. 1903–5 (1906), p. 24.

Station 339.

OPHIUROIDEA.

18. *Ophionotus victoriae*, Bell.

Ophionotus victoriae, Bell (1), p. 219.

Station 341.

19. *Ophiosteira antarctica*, Bell. (Pl. II, figs. 1–3).

Ophiosteira antarctica, Bell (1), p. 218.

This species, in its wide distribution and its great variability, is own brother to *Cycethra verrucosa*. Plate II shows three photographs of the remarkable differences in the plates of the disc.

Numerous Antarctic stations.

20. *Ophiacantha vivipara*, Ljungman.

Ophiacantha vivipara, Ljungman, Bell (2), p. 13.

Station 220, and off Inaccessible Island (Station 314).

21. *Astrotoma agassizi*, Lyman.

Astrotoma agassizi, Lyman, Bell (2), p. 15.

This also proves to be an exceedingly common form.

Stations 339, 341, 348.

B. NEW ZEALAND.

The basis of our knowledge of the Echinoderm fauna of New Zealand is an essay with that title published in the Proceedings of the Linnean Society of New South Wales, 1898, by Mr. H. Farquhar.

Eleven years later Prof. W. B. Benham, F.R.S., published a report on the Echinoderms collected by the New Zealand Government trawling Expedition in the Records of the Canterbury Museum, Vol. 1.

Among the specimens collected by the "Terra Nova" which were unknown to me were two Astrophiurids,* which I thought possibly might be recognised by Prof. Benham. This was not so, but he was kind enough to interest himself with the specimens, and to make on them some observations which have been of great value to me.

I have hardly any doubt that they are now described for the first time; the delay consequent on communicating with New Zealand has allowed Mr. H. L. Clark to describe a new species of *Ophiomyxa*, which was represented in this collection by a single specimen that might easily have been mistaken for *O. australis*.

The discovery of two specimens of *Ophiothrix* off the coast of New Zealand solves a problem of some importance, for, widely distributed as this genus is, it has not until now been known as a member of the New Zealand fauna.

No Astrophiurid was known from the waters of New Zealand till the year 1900,

* Cf. Bell, P. Z. S. 1892, p. 180.

when Mr. Farquhar* described a form which he called *Ophiocreas constrictus*; this Döderlein† has removed to the genus *Astrochema*.

The only other Astrophiurid known from New Zealand was described by Prof. Benham in 1909‡ under the name of *Astrotoma waitei*.

In describing, therefore, three new species of this division I more than double the number of species recorded from New Zealand waters.

I. ECHINOIDEA.

1. *Astropyga radiata*, Leske.

Three specimens from Station 96, 70 fathoms, 7 miles E. of North Cape.

2. *Laganum*, sp.

Two young specimens, which it is impossible to determine with accuracy, were taken at Station 96, 70 fathoms, off North Cape.

II. ASTEROIDEA.

3. *Asterina regularis*, Verrill.

Off New Zealand.

4. *Astropecten polyacanthus*, M. Tr.

Bay of Islands, and off North Cape.

III. OPHIUROIDEA.

5. *Pectinura*, sp., juv.

Station 96, E. of North Cape.

6. *Ophiothrix*, sp.

The fact that this genus has not been recorded from the neighbourhood of New Zealand is now one of the commonplaces of geographical distribution, but the genus is spread so widely through the seas that it was only natural to suppose that it would be discovered within this area, and it remained for the naturalists of the "Terra Nova" to find a single small specimen at a depth of 70 fathoms east of North Cape (Station 96), in company with a very small specimen of *Astroporpa wilsoni*, and two others from Station 144 (near Cape Maria van Diemen).

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* Trans. N. Z. Inst. XXXII, p. 405 (1900).
† Beiträge z. Naturg. Ostasiens, p. 113 (1911).
‡ Rec. Canterbury Museum, I, p. 101 (1909).

I do not recognise the species, which is probably new, and will add to the growing list of undescribed species, which can only be satisfactorily diagnosed when a complete revision is made of this extensive genus.

7. *Ophiomyxa brevirima*, H. L. Clark.

Ophiomyxa brevirima, H. L. Clark, Mem. Mus. Comp. Zoöl. XXV, no. 4 (December 1915), p. 169.

There is a single representative of this species, quite recently described by Mr. H. L. Clark from some specimens obtained at Otago Harbour, N.Z.

Station 96, east of North Cape: 70 fathoms.

Mr. Clark appears to doubt whether the specimens from New Zealand, which have been attributed to *O. australis*, have been correctly determined. As there is not in the collections of the Museum any specimen from any locality nearer than 39° 32′ S., 171° 48′ E., I am unable to discuss this question; but if the records are correct, *O. australis* is easily to be obtained from the shallow waters of New Zealand.

8. *Ophiocreas constrictum*, Farquhar.

Station 91, 25 miles off Three Kings Islands: 300 fathoms.

9. *Astroporpa wilsoni*, sp. n.

Station 96, E. of North Cape: 70 fathoms.

The upper surface of the disc has a more or less distinct central area covered with tubercles smaller than those of the periphery. These are well developed, and set in very regular rows, separated from one another by bare bands, and continuing the same character and arrangement on the upper surface of the arms.

The lower interbrachial areas of the disc are shagreen-like, very delicate and elegant; the arm-spines are numerous, very delicate, with minutely roughened surfaces. The tips of the arms form a more than usually close coil. There is a total absence of ornamentation from the plates, both of the arms and disc.

Colour, creamy white.

Diameter of disc, 13; 19 mm.

Length of arms (about) 50; 60 mm.

This genus was not known before from New Zealand.

10. *Astroschema elegans*, sp. n.

Station 96, E. of North Cape: 70 fathoms.

A somewhat variable species, but one that can easily be recognised by its well-marked coloration; preserved in spirit, it exhibits transverse reddish-brown bands separated by white spaces, which are often, though by no means always, wider than the red bands.

The disc, which is small, is marked by five pairs of rows of prominent plates, which might at a superficial view be taken for radial shields. These plates vary slightly in size and number, and are more irregular in larger than in smaller specimens.

The arms are long and coiled somewhat at their ends; there are no continuous arm-plates, but the calcareous plates deposited on the upper surface are arranged with great regularity, are oblong in form, and extend on to the sides of the arm, where they are less well developed; the spines on the lower surface are set in a single row on either side of the median furrow. The mouth is guarded by five prominent spines.

Diameter of disc, 9; 11; 12 mm.

Length of arms (about) 75; 90; 130 mm.

11. *Astrotoma benhami*, sp. n.

Station 91, 25 miles off Three Kings Islands: 300 fathoms. A single specimen.

The disc is completely covered with rather large coarse tubercles, not all of the same size, but the interbrachial spaces below are almost bare; the mouth-spines form simple clusters, and the papillae are encircled by well-marked granules which become spiniform towards the periphery. The arm-joints are closely covered by a pavement of granules, some of which are larger than others; there are two or three arm-spines on the sides of each joint. The arms are, in some specimens, closely coiled and creamy yellow in colour.

Diameter of disc, 11 mm.

Length of arm, 40 mm. (*ca.*).

C. SOUTH ATLANTIC.

The collection from the South Atlantic is not of particular interest, except for the discovery of a new species, the description of which will be found below; from Station 36 (South Trinidad) come *Echinometra lucunter* * of Linnaeus and *Echinocardium australe* of Gray; from Station 38 (52° 23′ S., 63° 50′ W., near the Falkland Islands) were taken a considerable number of specimens of *Ophiacantha vivipara*, Ljungman, some with seven rays and some with nine, and some bearing young. From Station 42 (22° 56′ S., 41° 34′ W., near Rio de Janeiro) were taken a number of *Astropecten pontoporaeus*, Sladen; from Station 42 also came the new species.

Luidia scotti, sp. n.

This species belongs to the group of *L. clathrata*, as defined by Mr. Sladen, but it is at once distinguished from that widely distributed form by greater delicacy of structure.

* For the synonomy of this form, see Lovén "On the species of Echinoidea described by Linnaeus" in Vet. Akad. Hdlgr. 13, IV, no. 5 (1887).

The five arms are marked with irregular patches of brown; they are rather delicate and tapering; their marginal plates are square, very regular, and equal in the upper and lower rows.

Inside the supero-marginals is a regular row of plates exactly like them, and within these are a number of rows of plates, which gradually decrease in size, and become more irregular in arrangement.

The arms are quite flat and taper regularly; there are two arm-spines, the lower of which is much the longer; the inner part of each arm-plate is crowded with spiniform granules of various sizes, and irregular in their distribution.

All the spines are pure white, while the podia are yellow.

The characters of this species, of which several specimens were collected, appear to be pretty constant.

R.	*r.*
58 mm.	11
65 mm.	9
69 mm.	10

Station 42, near Rio de Janeiro.

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PLATE I.

Cycethra verrucosa, Phil.

Figs. 1–6.—Six photographs to show the differences in the appearance of specimens due to the differences in the proportions of R to r, the varying bluntness of the arms, the form of the interbrachial curve, and the differences in the delicacy or coarseness of the granulation.

All from Station 314.

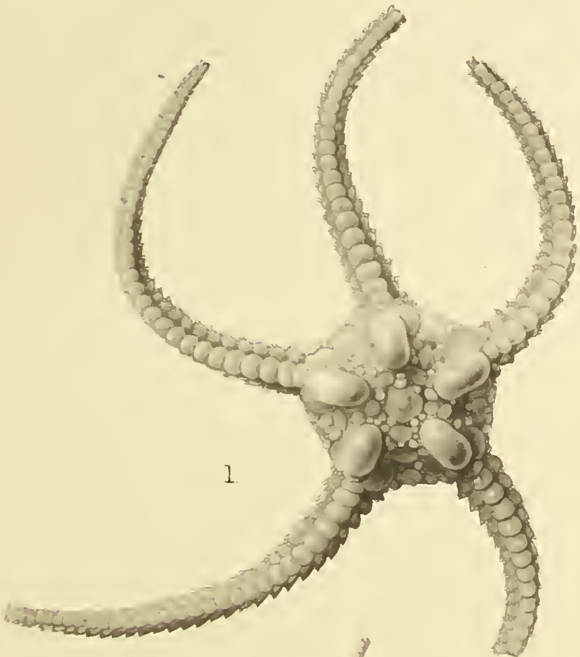
J. Green, Photo. del.
Bemrose Collo., Derby

PLATE II.

Ophiosteira antarctica, Bell.

Figs. 1–3.—Three photographs to show three very different stages in the size of the radial shields, and in the formation of the arm-joints.

All from Station 316.



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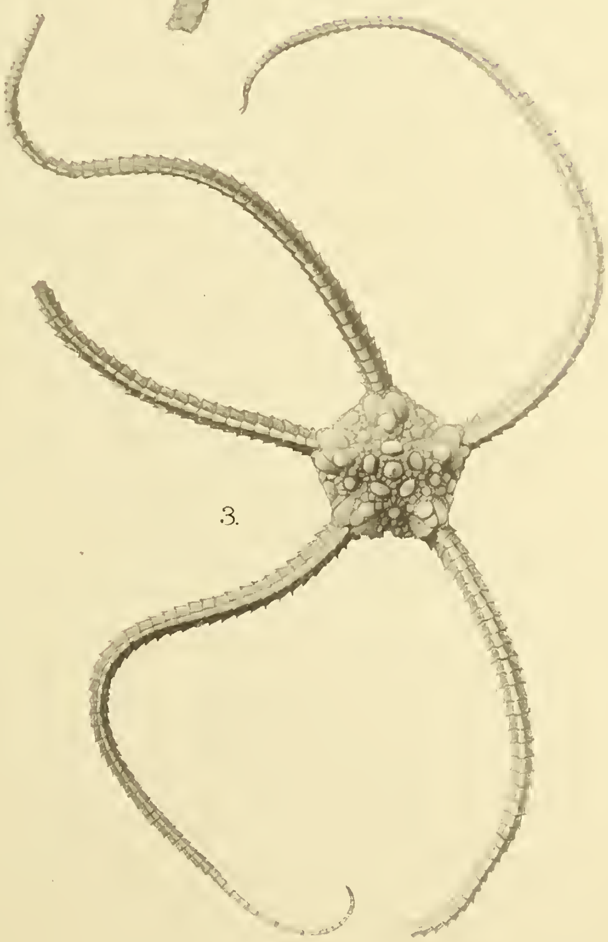

J. Green. Photo del.

Bemrose, Collo, Derby

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CEPHALODISCUS.

BY

W. G. RIDEWOOD, D.Sc.

LONDON:

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM.

British Museum (Natural History).

This is No. 3 *of* 25 *copies of "Terra Nova" Cephalodiscus, printed on Special paper.*

CEPHALODISCUS.

BY W. G. RIDEWOOD, D.Sc

WITH TWELVE FIGURES IN THE TEXT, FIVE PLATES AND A MAP.

CONTENTS.

MATERIAL.

The material of *Cephalodiscus* collected on the "Terra Nova" Expedition is of considerable bulk, and arrived at the British Museum (Natural History) on February 5th, 1914, in sixty-six bottles. Half of the bottles are of a capacity of $2\frac{1}{2}$ litres, the others are one-litre bottles, or of smaller size. Almost the whole of the material is preserved in 4 or 5 per cent. formalin solution, a small quantity of it in 70 per cent. alcohol. A few zooids of *Cephalodiscus hodgsoni*, *C. nigrescens* and *C. densus* had been specially fixed in corrosive sublimate solution, and subsequently transferred to 70 per cent. alcohol.

The material obtained from New Zealand proves to belong to a new species, for which the name *Cephalodiscus evansi* is proposed (p. 26). Unfortunately, only two small pieces of colony were obtained (plate 2, figs. 1 and 2). The rest of the material collected is referable to the three species *C. nigrescens* (p. 31), *C. densus* (p. 37), and *C. hodgsoni* (p. 48).

LOCALITIES.

The material of *Cephalodiscus* obtained on the "Terra Nova" Expedition was dredged from the following localities:—

Station 90.—July 25th, 1911; from Summit, Great King, Three Kings Islands, New Zealand, S. 14° W., 8 miles; 100 fms. (183 m.); dredge; bottom—rock.

Station 295.—January 27th, 1913; Ross Sea, 73° 51′ S., 172° 57′ E.; 190 fms. (348 m.); Agassiz trawl.

Station 314.—January 23rd, 1911; 5 miles N. of Inaccessible Island, McMurdo Sound; 222–241 fms. (406–441 m.); Agassiz trawl; bottom—mud.

Station 316.—February 9th, 1911; off Glacier Tongue, about 8 miles N. of Hut Point, McMurdo Sound; 190–250 fms. (348–457 m.); Agassiz trawl; bottom—undecomposed animal remains and mud.

Station 338.—January 23rd, 1912; entrance to McMurdo Sound, 77° 13′ S., 164° 18′ E.; 207 fms. (379 m.); Agassiz trawl; bottom—mud.

Station 339.—January 24th, 1912; entrance to McMurdo Sound, 77° 5′ S., 164° 17′ E.; 140 fms. (256 m.); Agassiz trawl; bottom—mud.

Station 340.—January 25th, 1912; entrance to McMurdo Sound, 76° 56′ S., 164° 12′ E.; 160 fms. (293 m.); Agassiz trawl; bottom—mud.

Station 348.—February 13th, 1912; off Barne Glacier, McMurdo Sound; 200 fms. (366 m.); Agassiz trawl; bottom—mud.

Station 355.—January 20th, 1913; Ross Sea, 77° 46′ S., 166° 8′ E.; 300 fms. (549 m.); Agassiz trawl.

Station 356.—January 22nd, 1913; off Granite Harbour, entrance to McMurdo Sound; 50 fms. (92 m.); Agassiz trawl; bottom—mud.

Of these ten stations, one (Station 90) lies to the north of New Zealand, and the others are in Ross Sea. Station 295 lies E.S.E. of Coulman Island, and the remaining eight stations are in McMurdo Sound, Stations 338, 339, 340 and 356 being at the entrance to the Sound, while Stations 314, 316, 348 and 355 are farther south, to the west of the southern part of Ross Island.

The yield from the several stations is set out in the table below, a cross indicating that material of the species named at the top of the column was obtained from the station enumerated at the left end of the horizontal line in which the cross occurs.

Station.	*C. evansi.*	*C. nigrescens.*	*C. densus.*	*C. hodgsoni.*
90	×	—	—	—
295	—	—	×	—
314	—	×	×	×
316	—	×	×	×
338	—	—	—	×
339	—	—	×	×
340	—	—	—	×
348	—	×	—	×
355	—	×	×	×
356	—	—	×	—

HISTORICAL INTRODUCTION.

The material of *Cephalodiscus dodecalophus*, dredged by the "Challenger" in 1876 from the Straits of Magellan, and described by M'Intosh and Harmer (14) in 1887,* remained for many years the sole representative of the genus *Cephalodiscus*.

In 1903 Andersson (1) announced the rediscovery of *Cephalodiscus* by the Swedish South-Polar Expedition, and Harmer † notified the discovery of new species by the "Siboga" Expedition. In his report on the Pterobranchia of the "Siboga" Expedition published in 1905 Harmer (10) described three new species, *C. gracilis*, *C. sibogae*, and *C. levinseni*, obtained from the east and south-east of Asia.

In the same year Lankester (12) gave a brief description of a species, *C. nigrescens*, obtained in Ross Sea by the "Discovery." Material of this species had apparently been obtained as far back as 1841 or 1842 by the "Erebus" and "Terror," but it remained in the British Museum unidentified and undescribed until 1912 (19).

* The full report was preceded by a preliminary notice in the "Annals and Magazine of Natural History," (5), X, 1882, pp. 337–348, and another in the Report of the British Association meeting of 1882, published 1883, pp. 596–597. The first published figures of *Cephalodiscus*, made from drawings supplied by Prof. M'Intosh, appeared in Sir E. Ray Lankester's article, "Polyzoa," in the "Encyclopædia Britannica," ed. 9, XIX, 1885, figs. 8–10. The "Challenger" material has been re-investigated by numerous workers, among whom may be mentioned Harmer (Zool. Anzeiger, Bd. XX, 1897, pp. 342–346; Siboga Report, Monogr. XXVI, *bis*, 1905), Masterman (Quart. Journ. Micro. Science, new ser., Vol. XL, pt. 2, 1897, pp. 340–366; Zool. Anzeiger, Bd. XX, 1897, pp. 443–450; Trans. Roy. Soc. Edinb., Vol. XXXIX, pt. 3, Dec. 1898, pp. 507–527; Quart. Journ. Micro. Science, new ser., Vol. XLVI, 1903, pp. 715–727), Cole (Journ. Linn. Soc., Zool., Vol. XXVII, no. 175, 1899, pp. 256–268), Schepotieff (Bergens Museums Aarbog, 1905, no. 8, pp. 20; Zool. Jahrb., Abth. für Anat., Bd. XXIV, 1907, pp. 553–608; *ibid.* Bd. XXV, 1908, pp. 405–491), and Ridewood (Quart. Journ. Micro. Science, new ser., Vol. LI, 1907, pp. 221–252).

† Zool. Anzeiger, Vol. XXVI, 1903, p. 593.

In 1906 Ridewood (16) published an account of *C. gilchristi* from South Africa, and in 1907 (17) gave detailed descriptions of Lankester's species, *C. nigrescens*, and a new species, *C. hodgsoni*, also of antarctic origin.

In 1907 Andersson (2) produced his report on the Pterobranchia of the Swedish South-Polar Expedition, in which he described five new species (*C. aequatus*, *C. inaequatus*, *C. solidus*, *C. densus* and *C. rarus*) from the South-American sub-antarctic region and the Graham Land part of the Antarctic Ocean.

An Indian species (*C. indicus*) was described by Schepotieff (22) in 1909, and an antarctic species (*C. anderssoni*) from near Graham Land was described by Gravier in 1912 and 1913 (5, 6 and 8). In 1913 Harmer and Ridewood (11) published an account of *C. agglutinans* obtained by the "Scotia" from the Falkland Islands.

Thus, disregarding the possibility of some of these specific names being synonyms,* fifteen species of *Cephalodiscus* have up to the present been described. The material now under consideration, obtained on the British Antarctic ("Terra Nova") Expedition of 1910–1913, includes large quantities of *C. hodgsoni* and *C. nigrescens* and a fair amount of *C. densus*, all from Ross Sea; also two pieces of a new species, *C. evansi*, from New Zealand.

CEPHALODISCUS AND *RHABDOPLEURA*.

Genus *Cephalodiscus*, M'Intosh.—Zooids small, living as a social community within a secreted coenoecium,† from the orifices or ostia of which they can emerge at will; coenoecium with a common branching cavity, or with a separate tubular cavity for each zooid and its buds. Body of the zooid consisting of three parts, with separate divisions of coelom; first part a shield, in the form of a flattened preoral disc, with a curved red line, used for crawling and for secreting the coenoecium, containing a single coelomic cavity, which opens to the exterior by a pair of pores; second part a collar-region, with a paired coelomic cavity, which opens to the exterior on each side by a ciliated canal; collar produced antero-dorsally into a lophophore of several pairs of arms, each arm with two rows of tentacles; collar produced laterally and ventrally into an oral lamella; central nervous system situated in the ectoderm at the bases of the arms; third part, the largest, a trunk-region, with closed coelomic cavity, primarily paired, containing the alimentary canal and gonads. Alimentary canal U-shaped, mouth ventral, behind the stalk of the shield; anus on the antero-dorsal surface of the trunk, near the bases of the arms. One pair of pharyngeal pores or gill-slits, near the collar-

* For arguments showing that *C. inaequatus* is the same as *C. hodgsoni*, see 11, pp. 559–563. A suggestion that *C. aequatus* also is not distinguishable from *C. hodgsoni* is put forward on page 59 of this report. Evidence that *C. rarus* is but a lax and straggling form of *C. densus* is adduced on pp. 39–40. The possibility of *C. anderssoni* also being the same as *C. densus* is discussed on page 40. As regards the two diminutive species of *Demiothecia*, Harmer writes (10, p. 4) that "the possibility is not excluded that *C. sibogae* is the male form of *C. gracilis*."

† See footnote, p. 57.

canals. A more or less tubular notochord projecting from the antero-dorsal wall of the pharynx; below it, in the shield, a pericardial sac, with heart. Gonads simple, one pair, opening by short ducts near the anus. Trunk prolonged posteriorly or ventrally, according to the degree of extension of the zooid, into a stalk, with a terminal sucker, around the edge of which buds are produced.

In consequence of the discovery of new species of *Cephalodiscus* since the time when the first description was written by M'Intosh, the original generic diagnosis (13, p. 348) has from time to time been emended by various authors.* In essential details the diagnosis given above, while adapted for the inclusion of all the species at present known, is substantially the same as those that appear in recent writings on the subject. Shield-pores, gill-slits and oral lamella are not known in the reduced males of *Cephalodiscus sibogae* (10, p. 6), but the neuter zooids of that species conform with the generic diagnosis in these respects. Females are not known.

The only other genus of the group Pterobranchia recognised is *Rhabdopleura*, the existence of which was known † some ten years before *Cephalodiscus* was dredged by the "Challenger" in 1876. The colony of *Rhabdopleura* is usually found growing upon a shell or stone. It is diminutive in size, with the zooids living in the tubes of a branching system, one zooid in each tube. The tubes are formed by lateral eruption from older tubes, and do not arise independently of the older tubes as is the case in the species of *Cephalodiscus* that are included in the sub-genera *Idiothecia* and *Orthoecus*. The tubes of these species of *Cephalodiscus*, however, resemble those of *Rhabdopleura* in that their length is increased by additions to the free edge. The increments are intermittent in both, so that the successive rings, and parts of rings, are distinct to the eye, although not readily separable by dissection.

The mode of budding is different in the two cases, and the system of branching differs as a direct consequence of this. Whereas in the species of *Cephalodiscus* in question (those of the sub-genera *Idiothecia* and *Orthoecus*) the young zooids, whether developed as buds or as larvae arising from fertilised ova, settle down and secrete each a tube of its own, in *Rhabdopleura* there is a proliferating stolon which

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* As showing the extent of the alterations that have had to be made in the generic diagnosis of *Cephalodiscus* since 1882, a transcript of the original diagnosis may be of some historical interest. "Coenoecium consisting of a massive, irregularly-branched, fucoid secretion resembling chitine, hispid with long spines of the same tissue, and honeycombed throughout by irregular apertures, channels, and spaces, in which the separate and independent polypides occur singly or in groups. Lophophore richly plumose, with an enormous buccal shield and large oral lamella, the mouth opening between the two. Anus on the anterior dorsal prominence, behind the plumes. Two large eyes abutting on the ovaries. The homologue of the funiculus is short and quite free, its tip serving for the development of buds." (13, p. 348.)

† *Rhabdopleura* was first dredged in 1866 by G. O. Sars off the Lofoten Islands, at a depth of 120 fathoms; it was mentioned by M. Sars in 1868 under the name *Haliophus mirabilis*, but was not described. New material, dredged by Canon Norman off the Shetland Islands from a depth of 90 fathoms, was described by Allman in 1869 (Quart. Journ. Micr. Sci., n.s., IX, 1869, pp. 57–63). Many papers have since appeared dealing with the structure of *Rhabdopleura*, and several new species have been described.

gives off buds in regular succession behind a terminal zooid. Each bud remains in that part of the axial or growing part of the colony in which it is formed, and becomes partitioned off by the formation of a transverse septum. It breaks through the side of the portion of the tube within which it is now imprisoned, and forms a lateral tube that is increased gradually in length by the secretion of successive rings at its edge. The bud enlarges and differentiates further, and becomes ultimately an adult zooid. The adults found in the open tubes do not themselves produce buds, and thus differ from the zooids of *Idiothecia* and *Orthoecus*.

As regards the general structure of the zooids, *Cephalodiscus* and *Rhabdopleura* have much in common; the body is divisible into the same regions in both—a shield, a collar-region with oral lamella and lophophoral arms, a comparatively large trunk-region, and a stalk connected with the trunk. In *Rhabdopleura* the arms are two in number, each with two rows of tentacles. In *Cephalodiscus* the arms may be as many as eight or nine pairs (*C. agglutinans*) and as few as three pairs (*C. indicus*). The male zooids of *C. sibogae* are of interest in this connection, for they have only one pair of arms, without tentacles, but the neuter zooids have four pairs of arms, with tentacles (10, pp. 6, 8 and 84).

Although gill-slits do not exist in *Rhabdopleura*, the position that these would occupy is clearly indicated by a pair of ciliated grooves. The alimentary canal of *Rhabdopleura* resembles that of *Cephalodiscus* in the relative positions of the mouth and anus, in the flexure of the gut, and in the presence of a notochord and a gastric caecum. The position of the central nerve-mass is another point in common.

SUB-GENERA OF *CEPHALODISCUS*.

Sub-genus *Demiothecia*, Ridewood.—Colony branching. Each ostium of the coenoecium leading into a cavity which is continuous through the colony, and is occupied in common by the zooids and their buds. Transverse sections of the branches showing the central cavity surrounded by a wall of coenoecial substance, usually of irregular thickness, and sometimes with inwardly projecting bars and ridges.

Sub-genus *Idiothecia*, Ridewood.—Colony branching. Each ostium of the coenoecium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common coenoecial substance, and disposed at a more or less constant angle to the surface; either blind at their inner ends, or connected up in the middle of the branch.

Sub-genus *Orthoecus*, Andersson.—Colony not branching, but in the form of a cake, or cone, or mass of irregular shape. Each ostium of the coenoecium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common

coenoecial substance, either for their whole length or towards their blind ends only; either closely set and parallel, more or less vertical, or irregularly bent and straggling.

To the sub-generic diagnoses Andersson (2, pp. 8, 10, 11) adds certain characters of the zooids, which I consider it desirable to omit, preferring to leave the three sub-genera to be determined by coenoecial characters alone. The characters mentioned by Andersson may be dealt with as follows:—

Firstly, the number of the arms borne by the zooids. In *Orthoecus* he gives the number as eight pairs; but he quotes no numbers for the other two sub-genera, thus rendering the application of the character incomplete. The occurrence of eight pairs is not confined to *Orthoecus*, for the number in *Cephalodiscus* (*Idiothecia*) *nigrescens* is sometimes eight pairs (more usually seven pairs, sometimes less). The number of arms, moreover, in certain species is not constant, notably in *C.* (*I.*) *nigrescens* (17, p. 32), *C.* (*I.*) *agglutinans* (11, p. 548), and *C.* (*D.*) *hodgsoni* (17, p. 55; 18, p. 230; 11, pp. 560–562; and pp. 62–64 of this report).

One is rather led to suspect that past investigators have been prone to accept as the normal number of arms in a species the greatest number found in a zooid, and have assumed that in the zooids in which smaller numbers occur some of the arms have been lost. Doubtless in many of these cases accidental injury during life, or violent contraction when the zooids are plunged into the preservative fluid, or rough treatment of the zooids by shaking during transit, may account for the number being below the maximum; but in the course of the present investigation there have come to light numerous instances of a complete lophophoral system, with less than the maximum number of arms found in the majority of the zooids of the particular colony, about which there can be no doubt that all the arms that the zooid possessed at the time of death are still present. The arms in such instances form a continuous series side by side, with no gaps except the usual interval between the arms of the median pair.

Sometimes there is to be seen between the outermost arm and the edge of the oral lamella a very small outgrowth, with or without lateral tentacles, representing an incompletely grown arm. The arms of *Cephalodiscus* develop successively in pairs (18), and not simultaneously, and it may be that the zooid in question is a young one in which all the arms are not yet developed. Some of the zooids, however, in which a rudimentary arm is found are of full size and with mature gonads, and it is more likely that the arm is permanently arrested in its development (text-fig. 12, p. 63). In other cases the vestigial arm is not the outermost or that nearest the edge of the oral lamella; it may be No. 3 or No. 4, for instance. Such may possibly be accounted for as the unsuccessful result of an attempt at the regeneration of an arm lost by injury during life. It is only in some instances that rudimentary arms such as these are found; in others the series is complete, without any gaps to suggest the loss of arms

or a deficiency in their number, and yet the number may be short of the maximum found in the species.

Secondly, the presence or absence of globular end-swellings, with refractive beads, at the ends of the arm-axes. These swellings, Andersson points out, are commonly present in *Demiothecia* (wanting in *C. sibogae* and in the hinder pairs of arms of *C. gracilis*), while absent in *Idiothecia* and *Orthoecus*. (See p. 21 of this report.)

Thirdly, the presence or absence of a short stalk to the membrane that encloses the free ovum. The stalk, he states, is present in *Demiothecia* (except in *C. gracilis*, and possibly in *C. sibogae*, of which females are not known), and absent in *Idiothecia* and *Orthoecus*. But in *C.* (*I.*) *gilchristi* the stalk is known to be present in some cases (**16**, p. 188, and **3**, p. 240).

Finally, the position of the ova within the ovary, whether they lie externally to the cavity of the ovary, as in *Demiothecia* (*e.g.*, **2**, plate 7, fig. 63, *C. inaequatus*), or bulge into the cavity, as in *Orthoecus* (*e.g.*, **2**, plate 7, fig. 64, *C. solidus*). This is a character the discovery of which we owe to Andersson himself (**2**, pp. 7 and 81–82); the application of it, however, he leaves incomplete so far as concerns *Idiothecia*, no species of which were obtained on the Swedish South-Polar Expedition. A re-examination of the serial sections of the type-material of *C.* (*Idiothecia*) *nigrescens* obtained by the "Discovery" shows an agreement between that species (text-fig. 3, p. 37) and Andersson's *C.* (*Orthoecus*) *solidus* (**2**, fig. 64).

Whether the ova lie externally to the ovarian cavity or bulge into it is a difference apparently due to the fact that in *Orthoecus* and in *C.* (*Idiothecia*) *nigrescens* the proliferation of the ovicells occurs unilaterally, on the side of the oviduct nearest the shield (text-fig. 3, p. 37; also **17**, plate 5, fig. 40), whereas in *C.* (*Demiothecia*) *hodgsoni* the small ovicells are more uniformly distributed around the lumen of the oviducal end of the ovary. The difference can only be made out in sections taken through the thin end of the ovary, for in the broadest part not more than one or two, rarely three, ova can be seen, and any space between them is just as likely to be an artefact, caused by a shrinkage of the ova, as it is to be the natural lumen of the ovary. It is clear from the small size of the ova in Andersson's figures 63 and 64 that the sections there represented were taken near the oviduct, and he definitely states in two places (**2**, pp. 81 and 82) that it is difficult to trace the ovarian cavity backwards into the ovary.

Limiting the sub-generic diagnoses to characters of the coenoecium, it will be noticed that the diagnosis for *Idiothecia* has had to be altered since it was founded (**17**, p. 10), so that it may include *C. agglutinans*, the inner ends of the coenoecial tubes of which are not blind. The affinities of *C. agglutinans* are so obviously with *C. levinseni*, *C. gilchristi*, and *C. nigrescens*, rather than with species of the sub-genus *Demiothecia*, that if the sub-genera are to represent natural divisions of the genus,

and not merely to form an artificial key for the identification of species, such amendment of the diagnosis was necessary (11, pp. 556–559).

The diagnosis of *Demiothecia*, also, has been recast so as to exclude *C. agglutinans*, the original diagnosis (17, p. 8) simply stating that there is a continuous cavity in the coenoecium, with all the ostia leading into it.

While there is a substantial difference between *Demiothecia* and *Idiothecia* as redefined above, the independence of *Orthoecus* from *Idiothecia* is not so well marked. The forms that are referred to the sub-genus *Idiothecia* can, on the whole, be distinguished by having a branched coenoecium, with the youngest tubes at the apices of the branches, whereas those of *Orthoecus* have a more cake-like coenoecium, with the youngest tubes around the edge or at some part of it, and the oldest and longest tubes in the middle of the mass.

As showing how ill-defined is the limit between *Orthoecus* and *Idiothecia*, it may be pointed out that Schepotieff (22, p. 435) places his species *C. indicus* in the sub-genus *Idiothecia*, whereas the coenoecium does not branch, but is cake-like, with all the ostia of the tubes set upon the upper surface. Possibly he was deterred from placing the species in the sub-genus *Orthoecus* by the fact that the tubes are not closely set, but have a fair amount of coenoecial substance between them; also possibly by the fact that *Orthoecus* is stated in the original diagnosis to have eight pairs of arms, whereas *C. indicus* has not, and so by default the new species had to be put in the sub-genus *Idiothecia*, in the diagnosis of which the number of arms is not stated.

Regarding the occupation of each of the tubes in a colony of *Idiothecia* by one zooid and its buds, it is to be noted that Gilchrist (3, p. 237) was fortunate enough to be able to study the zooids of *C. (I.) gilchristi* in a living condition, and observes that when they are drawn out of their tubes by means of a pair of forceps there appear to be more zooids than one in each tube. "In several cases," he remarks, "three or four zooids were found projecting from the aperture of one tube, part of their visceral region and all the buds being contained within the tube. These were sexually mature, with well-developed gonads, and, as far as could be made out, were quite independent of each other, though where they were embedded in the tube the buds were more or less interwoven, forming a solid mass, which was difficult to disentangle without making sure that no connection was broken."

This is an observation which conflicts so strongly with preconceived notions, based upon the examination of preserved material, that one is disposed to read the passage in close conjunction with Gilchrist's earlier statements in the same paper, that, in the living colonies which he was able to study, "the zooids and buds were on the surface of the coenoecium," the zooids were found either "at the entrance of the tube, on the spine, or even at some distance from the tube," "the general appearance suggested that the buds were acting as anchoring individuals for the fully-developed zooid," "on one or two occasions the whole cluster of buds and zooid was observed suspended

in mid-water by the much drawn-out and attenuated stalk of a bud, which was securely attached to the coenoecium by its sucker-like proboscis," "some of the large buds were seen to break at this point (proximal end of the stalk), and ultimately many isolated buds were found scattered over the general surface."

This freedom to wander over the surface, which had previously been noted by Andersson (2, p. 15) in living zooids of *C. inaequatus*, and had been suspected by the present writer from a study of preserved material of *C. hodgsoni* (17, p. 51), suggests at first that in those species of *Cephalodiscus* in which there are tubular cavities in the coenoecium (*i.e.*, the species of the sub-genera *Idiothecia* and *Orthoecus*) there is no rigid allotment of tubes to particular zooids, and that a zooid *may* retreat into a tube other than that from which it emerged. If this point be ceded, the main question to settle is—what is the normal condition? It may probably happen that, when alarmed, two or more zooids and their buds may withdraw for safety into the same tube, but it does not follow that they would remain thus associated for any length of time. From a study of the large amount of material that Dr. Gilchrist was good enough to send to the British Museum in 1905, in which material there certainly is a limitation of one zooid and its buds to each tube, I am disposed to believe that in natural conditions such a relation is maintained, but that in what one may term "laboratory conditions" the disturbed zooids take shelter in the tubes that happen to be nearest and most convenient.

Another answer to the question is furnished by Harmer in his appendix to Gilchrist's paper (3, p. 244), that the occurrence of several zooids in the tubes "indicates, in all probability, that some of the buds have assumed an adult character."

Even in *C.* (*I.*) *agglutinans*, in which the tubes of the coenoecium communicate at their inner ends with a labyrinthic tubular system in the middle of the branch (11, p. 538), the probability is, so far as can be judged from a study of preserved material, that each tube that opens externally is the dwelling of but one zooid and its buds (11, pp. 540 and 559).

ZOOIDS OF *CEPHALODISCUS*.

Notwithstanding considerable differences in the form of the coenoecium in the various species of *Cephalodiscus* recognised, the anatomical structure of the zooids is remarkably similar throughout the genus. Only in the reduced male zooids of *C. sibogae* is there any marked departure from the average structure; these have but one pair of arms, which are devoid of tentacles; there are no gill-slits and no shield-pores, and the alimentary canal is reduced. With this exception, the slight differences that are noticeable between the various species are those affecting the size of the body, the degree of pigmentation of the surface, the proportions of the shield, stalk, stomach and gastric diverticulum, the length of the testes, the number and shape

of the arms, the mode of termination and the characters of the epidermis of the arm-axes, and the measurements of the notochord.

The extreme mobility of the shield in life leads to very considerable differences in the appearance of the shields of zooids of the same species after death, and this renders a comparison of the shields of the different species a matter of practical difficulty; one can only utilise the organ for taxonomic purposes by taking an average of measurements of a large number of selected examples. The structure of the shield is essentially the same in all; the posterior lobe is thinner than the anterior, and the curved red line is constant.

Regarding the number of the arms of the lophophore, it is to be remarked that in some species the numbers fluctuate considerably (p. 17), and it is not safe to trust to results obtained by the cutting into serial sections of a few zooids. The more reliable method is to examine a large number of individuals, each zooid being dissected in diluted glycerine * under a Zeiss binocular erecting microscope (oculars—No. 2 or No. 4; objectives—No. a3) by means of two mounted needles (English size No. 12 or No. 14), the points projecting not more than 5 mm. so as to avoid undue flexibility. The shield of the zooid is first removed, and the arms are detached one at a time by severing their bases. The body is then dissected open to extract the gonads, so that the same dissections may serve for determining the sex. A cover-glass is put on, and ringed with zinc-white cement. Such dissections, if the slides are placed in trays so that they may remain horizontal, will keep for a considerable time, and are thus available for subsequent study.

The mode of termination of the arm-axes, whether possessing end-swellings with refractive beads or not, is a fairly good character for specific distinctions, although not for defining sub-genera (see p. 18). In the zooids of *C. hodgsoni* obtained by the "Terra Nova" it occasionally happens that an arm has no end-swelling (text-fig. 12, B, p. 63). The deficiency does not necessarily affect the same arms in different zooids, and it may be unilateral, one arm alone, perhaps, out of a total of ten or twelve being thus defective; or, on the other hand, several arms of the same zooid may be without end-swellings. The condition rather suggests that the extremity has been lost during life, and the end of the arm has healed up without the end-swelling being regenerated.

Although in species of *Idiothecia* and *Orthoecus* isolated instances occur, possibly one arm in six or eight zooids, in which the extremity of the arm-axis is slightly enlarged (*e.g.*, *C. gilchristi*, 16, p. 185, text-fig. 2, B; *C. agglutinans*, 11, p. 549, text-fig. 4, C; *C. nigrescens*, 17, plate 5, fig. 23; and *C. densus*, text-fig. 6, F, p. 45 of this report), yet this is a form of termination clearly distinct from the bulb-like end-swellings, studded over with highly refractive beads, that are present with such

* Equal parts of pure glycerine and distilled water, with a small crystal of thymol dropped into the bottle a few weeks before the fluid is used.

regularity on the arms of *C. dodecalophus* (17, p. 4, text-fig. 1) and *C. hodgsoni* (17, plate 5, figs. 32–35); and so far as present knowledge goes, these characteristic "end-swellings" are confined to species of the sub-genus *Demiothecia.* In *C. gracilis* they do not occur regularly in the adult, although they are present on the first pair, and sometimes on the second and third pairs of arms of the buds, and occasionally persist in full-grown zooids (10, pp. 20 and 94). They do not occur on the arms of neuter zooids of *C. sibogae,* but in the reduced males, particularly young males, the refractive beads are met with in profusion along the whole course of the two arms (10, pp. 21 and 84).

In *Orthoecus* Andersson (2, p. 11) states that end-swellings do not occur, and one consequently suspects that there must be some inaccuracy in his figure of the zooid of *C.* (*O.*) *rarus* (2, plate 4, fig. 22), for it shows end-swellings far more distinct than those represented in his figures of *C.* (*D.*) *inaequatus* (plate 4, figs. 17–21). Independent examination at the British Museum (Natural History) of zooids of *C. solidus* and *C. densus* obtained on the Swedish South-Polar Expedition confirms the statement by Andersson that end-swellings with refractive beads are not present.

The peculiarities of the epidermis of the arm-axis noted by Andersson in dealing with his three species of *Orthoecus* (2, pp. 11–12) do not as specific characters inspire one with confidence, for so much depends upon the degree of extension of the individual arms at the time of death of the zooid. The cells in question are tall epithelial cells on the neural surface of the axis, opposite the ciliated groove, and, according to the observations of Andersson, they occur to a different extent in the three species. In *C. solidus* the tall cells are present on the extremity of the arm and along the distal half of the length of the neural surface of the axis; they fail to stain with haemalum and eosin, and in serial sections remain markedly transparent. In *C. densus* and *C. rarus* the peculiar epithelium does not occur at the actual extremity of the axis; in *C. densus* the cells for a short distance near the end are slightly taller than elsewhere, and stain feebly or not at all; in *C. rarus* the epithelium of the distal half of the arm is composed of tall cells, those nearer the extremity remaining unstained or but feebly stained, while the others, more irregular in their disposition, stain blue.

Examination of zooids of the specimens of these three species that were received by the British Museum (Natural History) from the Stockholm Museum shows that the differences recorded are not constant. The actual tip of the axis of the arm of *C. solidus* really resembles that of *C. densus* and *C. rarus* in not having the tall epithelium conspicuously developed; in Andersson's fig. 10 the end of the axis is so strongly incurved that the actual extremity is not clearly seen. In one zooid of *C. solidus,* dissected and mounted in glycerine in such a manner that all the sixteen arms can be examined separately, there is considerable variety among the arms so far as the disposition of the tall epithelium is concerned, and the differences are to some extent associated with differences in the degree of contraction of the arms. Two

of the arms have much the same character as that shown in Andersson's figure; the end of each is incurved, the tall epithelium occurs on the distal half of the axis, and not on the proximal half. Two arms show the tall epithelium disposed along the axis almost to the base, and two others are in fairly full extension, longer than the average, with the end of the axis tapering to a blunt point. The general condition of these last arms recalls that shown in Andersson's figure of *C. densus* (2, fig. 8) rather than that shown in the figure of *C. solidus* (fig. 10).

There is no doubt that the epithelium of the neural surface of the axis in the three species of *Orthoecus* under consideration is different in character from the general epithelium of the aponeural face and the tentacles, but how far the enlargement of the cells is unnatural and due to the particular fixing reagents employed can only be determined by a comparison of zooids from portions of the same colony fixed by different methods (cf. *C.* (*I.*) *nigrescens*, p. 36).

The degree of pigmentation of the body is a character that must be utilised with caution, for Gilchrist has recently shown (3, p. 239) that the living zooids of *C. gilchristi* are blackish, and that the colour dissolves out into the preservative fluid; if the fluid is changed frequently, the colour of the zooid becomes pale, with just a dark anterior edge to the shield. Andersson has, moreover, observed that the zooids of *C. inaequatus* are red when alive, the trunk being darker than the other parts (2, plate 1); but in the preserved state they are reddish brown, pale brown or cream-coloured. Partial solution of pigment by the action of preservative fluids had been previously suspected in zooids not known in the living state (*C. nigrescens*, 17, p. 25, zooids fixed in picric acid solution), and it is surmised in the case of *C. agglutinans* (11, p. 544). Of further interest in this connection is the fact that in preserved material of *C. solidus* the zooids in the deeper parts of the colony are blackish, but those in the more superficial tubes, and zooids that have been removed from their tubes, fade—presumably by the action of light—to a pale brown, or yellow (ochreous), or cream-colour. Oddly enough, the red line in the shield and the red mass at the oviducal end of the ovary seem to retain their colour in all the usual preservative fluids, and to resist the fading effect of light.

The size of the body of the zooid is a character to which little value is attached by Andersson, who has had the good fortune to study the zooids alive. The body of *Cephalodiscus* is so mobile and protean that, whereas in preserved material the stalk is not infrequently short, thick, and wrinkled, and connected with the ventral surface of the body at about two-thirds or three-quarters of the length from the mouth, in a well-extended living zooid the body tapers off posteriorly into the stalk, which is of considerable length and slenderness, and the body has no caecal end such as is present in preserved specimens. It may here be pointed out, however, that most of the material that investigators have to deal with is material that is sent to museums and laboratories in a preserved state, and it certainly is to a large extent possible to compare the sizes of dead zooids with a fair degree of conviction that the measurements

are of value. By selecting zooids that are moderately extended, not too attenuated, and not too distorted by excessive contraction, it is possible to take three useful measurements—from the caecal end of the body to the front of the body (bases of the arms, or the anus), from the caecal end of the body to the free extremities of the arms, and, thirdly, the diameter of the body.

In the Report of the National Antarctic ("Discovery") Expedition (17, pp. 9–11) the measurements of the zooids are given as from the front of the shield to the extremity of the body; but owing to the fact that the shield may be displaced, distorted or injured, it is now found that for practical purposes the measurement from the anal end of the body, at the bases of the arms, to the caecal end of the trunk is more reliable for purposes of comparison of the zooids of different species.

Gravier has pointed out (8, p. 73) that *Cephalodiscus* affords a good instance of gigantism in polar regions, both as regards the size of the zooids and the bulk of the edifices that they build. He notes the large size of *C. solidus*, *C. anderssoni*, and *C. nigrescens*, which are antarctic forms, in contrast with the diminutive character of the tropical forms *C. indicus* (6°–11° N.),* *C. gracilis* (1° N.), and *C. sibogae* (4° S.). While the thesis is correct in the main, it must be admitted that it does not apply with precision throughout the genus, for *C. hodgsoni* is an antarctic form, and is not much larger than the sub-antarctic *C. dodecalophus*. Further, the zooids of the new species (*C. evansi*) obtained on the British Antarctic ("Terra Nova") Expedition are about twice as long as those of *C. gilchristi*, the material of which was dredged from the same latitude (*C. evansi*, 34° S.; *C. gilchristi*, 33°–35° S.). And *C. levinseni*, which was obtained at the same distance north of the Equator (32° N.) as *C. evansi* and *C. gilchristi* were obtained south of it, is intermediate, in the length of its zooids, between these two species, but the zooids are thinner than those of both species.

It is doubtful whether the relative length of the stalk as found in preserved zooids has much value, for in life the stalk is now known to vary enormously; but the length of the stalk in preserved zooids is in a sense a measure of its muscularity, and the general appearance of zooids killed rapidly in the fixing fluid is largely determined by the relative contraction of the stalk. It is quite conceivable, however, that if a living colony were divided into two, and one part plunged immediately into a fixing fluid, while the other part was fixed later, when the zooids were in a moribund condition, the zooids of the former would exhibit a shorter and more contracted stalk than those of the latter part.

A character to which Andersson directs attention (2, pp. 7–8, 32) is the occurrence of three longitudinal thickenings in the nerve-tract on the ventral side of the stalk in the species of *Demiothecia* examined by him, and the presence of a single thickening in the species of *Orthoecus*. While this may possibly prove to be a useful character for the identification of a species, it does not follow a natural grouping of the species

* The latitudes are here given to the nearest degree; for more precise data, see Synopsis, pp. 66–77.

of *Cephalodiscus* known, for it has been shown (11, pp. 553–554) that the triple thickening occurs in *C.* (*D.*) *dodecalophus*, *C.* (*D.*) *hodgsoni*, *C.* (*D.*) *aequatus*, and *C.* (*I.*) *nigrescens*, and the single thickening in *C.* (*D.*) *gracilis*, *C.* (*D.*) *sibogae*, *C.* (*I.*) *levinseni*, and *C.* (*I.*) *agglutinans*. In *C.* (*I.*) *gilchristi* the thickening is triple, and in *C.* (*I.*) *evansi* it is single. The character is difficult of application, owing to the fact that the lateral thickenings in the species with a triple nerve-tract are never very pronounced; they are not separate nerve-tracts, but merely slight thickenings of a continuous sheet of nervous tissue that is but feebly differentiated in any case, and is still sub-epidermal in situation.

The length and diameter of the notochord are characters which Andersson (2, pp. 58–62) utilises as a means of discriminating between the various species of *Cephalodiscus* obtained on the Swedish Expedition. He points out, moreover, that the anterior or distal end is swollen and bent upwards in the species of *Demiothecia*, but is not swollen nor sharply bent in the species of *Orthoecus*. In *C.* (*Idiothecia*) *nigrescens* the extremity is neither swollen nor bent (17, p. 34, text-fig. 10), but in *C.* (*I.*) *gilchristi* the end is bent upwards, though not swollen (16, p. 186, text-fig. 3). A section taken through the middle of the length of the notochord of *Cephalodiscus* is usually oval, the vertical diameter being less than the horizontal diameter; but observations made on several series of sections of zooids of *C. densus* obtained by the "Terra Nova" go to show that in different zooids of the same species a transverse section through the notochord may vary in shape from a circle to a very elongated ellipse, and the only measurement that can in any way be regarded as constant is the mean of the vertical and horizontal diameters (see p. 48).

The length of the testis is a character which has been rather neglected for purposes of classification, yet it seems to have some value. In some species (*e.g.*, *C. hodgsoni*, 17, plate 5, fig. 41) the two testes are globular, ovoidal or pyriform, whereas in other species the testes are several times as long as they are wide (*e.g.*, *C. nigrescens*, 17, plate 5, fig. 37, and *Orthoecus*, 2, p. 84). Although the character may prove useful in the determination of a species, it does not, one must admit, follow what may be regarded as the natural affinity of the different species; for the testes of *C.* (*I.*) *gilchristi* (16, p. 189, text-fig. 5) are short, like those of *C.* (*D.*) *hodgsoni*, and not long, like those of *C.* (*I.*) *nigrescens*; and the testes of *C.* (*D.*) *sibogae* (10, plate 7, fig. 76) are long, whereas in other species of *Demiothecia* in which the testes are known they are short.

When the testes are of the long variety, there may be in a zooid either two moderately long testes (length five to eight times the width) or one very long testis and a shorter one; the longer testis frequently extends to the caecal extremity of the body, and may project into the stalk. Immature zooids must be avoided in determining the relative length of the testes, for young testes are comparatively short in the zooids of species characterised by the possession of long testes in the adult state.

There is not a marked difference between the ovaries in the different species; the ovaries are usually globular or pyriform, the length being rarely more than three or four times the width, although in young ovaries this proportion is sometimes exceeded. The longest ovaries occur in the species of *Orthoecus*.

The early or late stage at which the arms make their appearance in the buds is a character which may prove of some assistance in discriminating between the various species of *Cephalodiscus*. Buds with three or four pairs of developing arms have a relatively small shield in some species, and a very large shield in others. In *C. dodecalophus* and *C. hodgsoni* the first pair of arms reach the front edge of the shield at a stage when three pairs of arms are recognisable (18, p. 231, text-fig. 4, G and H; and p. 225, text-fig. 2, G), and the buds of *C. aequatus* and *C. inaequatus* in material collected on the Swedish South-Polar Expedition have been found to agree very closely with them (11, p. 556). The same relation evidently obtains in *C. gracilis* (10, plate 1, figs. 4 and 9, and plate 3, figs. 30–32), although the particular stage with three pairs of arms developing is not figured. On the other hand, in *C. agglutinans* (11, p. 555, text-fig. 5, D), *C. nigrescens* and *C. gilchristi* (18, p. 236, text-fig. 6, D, and p. 243, text-fig. 9, G), and in *C. solidus* (21, text-fig. 3, D) and *C. densus* (text-fig. 8, F, p. 47 of the present report) the arms at the stage when three pairs are developing are but insignificant bead-like outgrowths from the collar-region, and are very remote from the edge of the shield.

CEPHALODISCUS EVANSI, n. sp.

Cephalodiscus (*Idiothecia*) *evansi*, n. sp.—Colony massive, branching; largest piece known, a single branch, 47 mm. high, 19 mm. wide, not including peristomes. Coenoecium friable, cream-coloured, speckled, containing large quantities of shells of Foraminifera and fragments of shells of Molluscs and Echinoids. Ostia at the ends of tubular peristomes that project 2·5 to 4·5 mm. beyond the surface of the branch; ostium set obliquely, sometimes squarely, at the end of the peristome, without definite lip or spine. Each ostium leading into a tube that ends blindly in the middle part of the branch. Width of cavity of the tubes, 0·6 to 0·8 mm.; length of tube, including peristomial part, 10 to 25 mm., but shorter than 10 mm. at the apex of the branch. Zooids—length from free ends of the arms to end of body of a fairly extended zooid, 3·5 mm.; length from bases of arms to end of body, 2·3 mm.; width of body, 0·7 mm. Colour (of zooids preserved in formalin solution) pale green or white, with the red line of the shield very conspicuous. Arms usually eight pairs, sometimes nine or seven pairs; no end-swellings with refractive beads. Male and female zooids occurring in the same colony. Hermaphrodite zooids (with one ovary and one testis) not known. Testes long. Free ova not known. Buds several to each zooid, up to nine.

Material of *Cephalodiscus evansi* was obtained from Station 90, off New Zealand; from summit of Great King, Three Kings Islands, S. 14° W., 8 miles; Lat. 34° 15′ S.; Long. 172° 4′ E.; 100 fms. (183 m.); July 25th, 1911; bottom, rock.

The species is named *C. evansi* after Commander E. R. G. R. Evans, C.B., D.S.O., who did valuable work as second officer of the shore-party of the British Antarctic ("Terra Nova") Expedition, and has more recently given further evidence of his sterling character, resource and enterprise while in charge of H.M.S. "Broke."

The material consists of two pieces only, the larger (plate 2, fig. 1) measuring 47 mm. high and 19 mm. wide, not including the projecting peristomial tubes. This is clearly a branch of a large, rather massive colony, and the smaller piece may possibly have been broken off from its basal end; but the two pieces do not fit accurately together, owing to a rounding off of the surfaces, occasioned, no doubt, by the shaking and attrition within the bottle which the specimens must have experienced before they were handed over for investigation.

C. evansi is an arenaceous form of *Cephalodiscus*, resembling *C. agglutinans* in general appearance, but with peristomial tubes projecting 3 or 4 mm. from the general surface of the coenoecium, whereas in *C. agglutinans* it is only the short spines that project. In the present species there are no spines.

The ostia are occasionally set transversely at the ends of the peristomial tubes, but more usually the tubes are obliquely cut, sometimes, as in the upper part of the larger specimen (plate 2, fig. 1), so obliquely as to suggest the presence of a lip at the outermost part of the edge. The superimposed layers of coenoecial substance constituting this projection are, however, continued all round the ostium, so that there is not the same definite growth of lip as occurs in *C. nigrescens*, *C. solidus*, and *C. levinseni*. While the peristomial tube is strongly ringed by lines of growth, the rings become fainter below as one follows the tube inward, and they disappear long before the blind end of the tube is reached (text-fig. 1).

The peristomial tubes measure from 2·5 to 4·5 mm. in length, but at the apex of the branch they are shorter than the average; the peristomes are here paler and more delicate, and more crowded than those on the sides. All these features indicate that the youngest tubes occur at the free end of the branch, and that the mode of growth of the colony is probably the same as has been suggested in the case of *C. nigrescens* (17, p. 23).

The general resemblance of the branch to one of the more slender branches of *C. agglutinans* is but a superficial one, and is mainly due to the multitude of extraneous particles embedded in the coenoecial substance. The foreign particles are rather less abundant than in *C. agglutinans*; they are mostly white in colour, and consist of shells of foraminifera and young gastropods, fragments of molluscan shells, both gastropod and lamellibranch, spines of echinoids and silicious sponge-spicules.

The form of *Cephalodiscus* obtained by the "Scotia" was designated *C. agglutinans* because the characteristic appearance of the coenoecium was due to the agglutination.

within the soft coenoecial substance between the inhabited tubes, of large quantities of shells and fragments of shells. It was not imagined, however, that the habit of agglutination was confined to that species (11, p. 542), for it had already been observed, though to a less marked extent, in the case of *C. sibogae* (10, plate 2, figs. 17, 18), *C. densus* (2, p. 12), *C. solidus* (2, p. 11), *C. aequatus* (2, p. 10), *C. nigrescens* (19, p. 551 ; and 8, p. 75), and *C. anderssoni* (6, pp. 147–8 ; and 8, p. 80).

The presence of large quantities of shell-fragments within the soft coenoecial substance of *C. evansi* gives a speckled, cream-coloured appearance to the branch, and renders it extremely friable.

Each peristome is continued within the substance of the branch as a tube that is inhabited by a single zooid and its buds. The deeper, embedded parts of the tubes are composed of extremely thin films of tough coenoecial substance, transparent, and of a pale amber colour, in marked contrast with the jelly-like, soft, colourless coenoecial substance that fills in the intervals between the tubes.

The tubes themselves do not include in their walls any of the shell-fragments that occur between them in the substance of the branch, but some of the shelly particles are so tightly affixed to the outer surface that in tracing out a tube great care has to be exercised in order to avoid tearing it, and this in spite of the fact that its thin wall is so tough.

The extreme transparency of the tubes of the colony adds to the difficulty of tracing them out. Good results could undoubtedly be obtained by adopting the method of decalcification that proved so useful in tracing out the tubular labyrinth of *C. agglutinans* (11, p. 538), but the small amount of material available rendered the method undesirable, for it would have meant the destruction of all the zooids in the piece of colony thus treated. Since only two pieces of colony were obtained, the tracing of the tubes and the extraction of zooids for study were effected mainly upon the smaller piece. The larger and more shapely piece (plate 2, fig. 1) is thus left comparatively uninjured.

The tubes do not anastomose as they do in *C. agglutinans*, but each ends blindly in the middle part of the branch, a feature in which the present species resembles *C. nigrescens*, *C. levinseni*, and *C. gilchristi*. The tubes are not uniformly distributed in the interior, for while the majority are separated from one another by soft coenoecial substance and shell-fragments for about twice the width of a tube, other tubes are in places actually in contact with one another (plate 5, fig. 9).

The surface-film of soft coenoecial substance is definite and continuous, but in the middle part of the branch the amount of secreted material holding together the particles of shell, etc., is very small, so that the tubes seem to be traversing a mass of shell-fragments only. The thin superficial layers that cover the soft common coenoecial substance are continued outward on the sides of the peristomial tubes, as shown in text-fig. 1, a.

The longest tube dissected out measures 21 mm. from the ostium to the blind end,

but there is evidence to show that some tubes are longer than this, probably 25 mm. ; some tubes are as short as 10 or 12 mm. ; at the apex of the branch they are even shorter than 10 mm. The width of the cavity of the tubes varies from 0·7 or 0·8 mm. at the peristomial end to 0·6 or 0·7 mm. in the middle and inner parts.

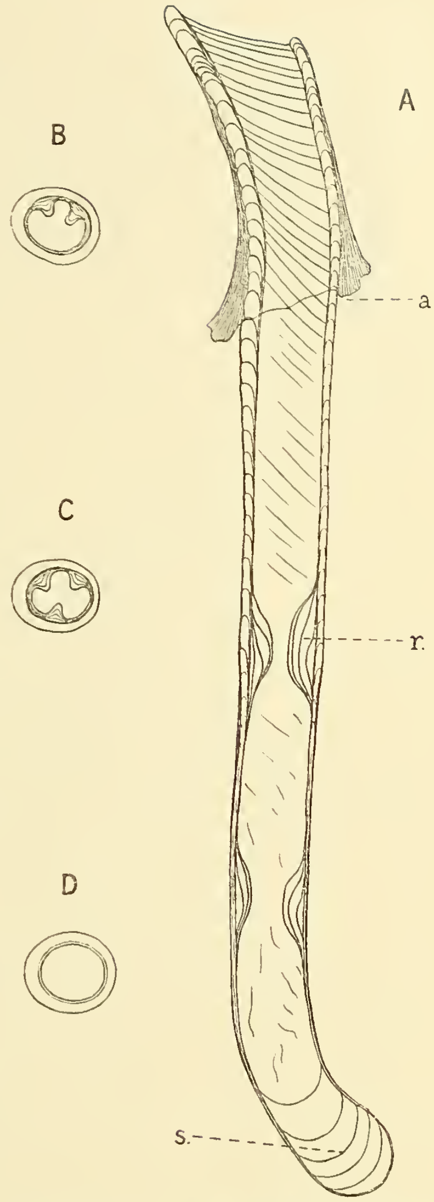
The blind end of a tube has a very thin wall; it is slightly dilated into an irregular bulb, as in *C. nigrescens*, and may have as many as five or six curved septa (text-fig. 1, A, s). This part of the tube is frequently bent at an angle to the length of the tube.

The deeper parts of the tubes—*i.e.*, those nearest the axis of the branch—are in places curiously wrinkled and distorted; in other places irregular longitudinal ridges project inward, and yet the outer surface of the tube is smooth (text-fig. 1, r).

In rare instances a zooid can be seen without cutting into the coenoecium, but in most cases the zooids have retreated to the middle of the length of their tubes. The zooids are white in colour, some of them with a greenish tinge on the trunk, but not on the arms. The curved red line of the shield shows up very strongly by contrast with the rest of the body. Owing to the whiteness of the zooids they are, in a teased up piece of branch, difficult to distinguish among the numerous shell-fragments, but the red line of the shield is so conspicuous that it indicates the presence of a zooid even to the unaided eye.

Eight zooids in a fair state of extension were measured, and the averages of the figures obtained are :—length from the free ends of the arms to the caecal end of the trunk—3·5 mm. ; length from the bases of the arms, or from the anus, to the end of the trunk—2·3 mm. ; width of the body—0·7 mm. The length of a moderately well-extended stalk is 3 or 4 mm.

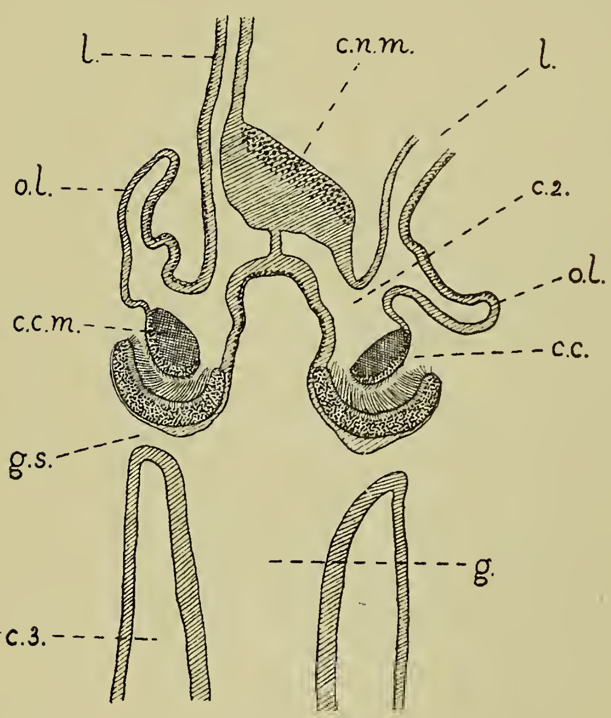
The arms are mostly eight pairs, sometimes nine or seven pairs; they are colourless, and have



Text-fig. 1.—*Cephalodiscus evansi.* A—side view of a comparatively short tube dissected out from the common coenoecial substance; B and C—transverse sections of a tube in the region of internal ridges; D—transverse section of a part of a tube free from such ridges. (× 12.) *a*, level of the general surface of the branch: the part of the tube above this point is the peristomial tube, the part below it is surrounded by common coenoecial substance; *r*, internal longitudinal ridges; *s*, septa in the blind end of the tube.

no end-swelling with refractive beads. In extended arms the axis is slender and straight; in contracted arms the axis shows a thickened epidermis on the neural surface, extending over the distal half or two-thirds of the length, and in many cases the extremity of the axis is incurved towards the grooved, aponeural surface. The outer edge of each lobe of the oral lamella is scalloped, with six, sometimes seven, well-marked projections.

Male and female zooids occur in different tubes of the same branch of the colony. Hermaphrodite zooids, having one ovary and one testis, were not found. The ovaries are much the same as occur in *C. nigrescens* (17, plate 5, figs. 38, 39, 40), and have red oviducts. No free ova were found in the tubes. The testes are long, either one very long testis and a shorter one, or both of moderate length. The spermatozoa have long, tapering heads, and resemble those of *C. densus* (text-fig. 7, F, p. 46), but are a little smaller.



Text-fig. 2.—*Cephalodiscus evansi*. Composite figure of *camera lucida* drawings of three consecutive sections taken parallel to the face of the shield. (× 150.) Thickness of the sections — 0·007 mm. *c.2*, collar coelom; *c.3.*, trunk coelom; *c.c.*, collar canal; *c.c.m.*, collar canal muscle; *c.n.m.*, central nerve-mass; *g.*, cavity of gut; *g.s.*, gill-slit; *l.*, base of the lophophore, *o.l.*, oral lamella.

The material when collected was dropped into formalin solution, and was not specially preserved with a view to microscopical investigation, but the following features can be made out from the examination of serial sections and dissected preparations.

The notochord is straight, and not bent up at the tip; its length is about 0·24 mm. The thickest part is situated at about one-sixth of the length from the tip, and tapers off anteriorly from this region. The transverse sections of the proximal and distal parts of the notochord are mostly circular or elliptical in outline, but those taken through the middle of the length are in some zooids nearly circular, while in others they are so compressed dorsoventrally that the cavity is practically obliterated, and the outline is very broad in comparison with its height. Taking in each case the mean of the vertical and horizontal diameters of the transverse sections, the average measurements are—near the distal extremity 0·043 mm., in the middle of the length 0·027 mm., near the base 0·021 mm.

The collar-canals (text-fig. 2, c.c.) are large and curved, with both external and

internal openings directed forwards; the two orifices are approximately of the same size. The nerve-tract in the stalk is single.

Several buds occur at the end of the stalk of the zooids, the greatest number found being nine. The stalks are long, and there is reason to suspect that the zooids and buds were dead and in a relaxed state at the time when the pieces of colony were placed in the preservative solution. The buds are white, with the red line very prominent, except in the youngest buds. In the middle of the shield is a circular grey area. In the late development of the arms in the buds, or, in other words, the large size of the shield at the time when the arms begin to appear, *C. evansi* resembles *C. agglutinans* (11, text-fig. 5, p. 555), *C. gilchristi* (18, text-fig. 9, p. 243), *C. nigrescens* (18, text-fig. 6, p. 236), and *C. solidus* (21, text-fig. 3).

CEPHALODISCUS NIGRESCENS, Lankester.

Cephalodiscus (*Idiothecia*) *nigrescens*, Lankester.—For diagnosis, references and list of recorded specimens, see page 73.

MATERIAL COLLECTED.

Material of *C. nigrescens* was obtained from Stations 314, 316, 348 and 355, all of which are in McMurdo Sound, Ross Sea. For details as to depths and dates, and the precise position of each of these Stations, see page 12.

The material from the first three stations is considerable in amount:—from Station 314 eighteen bottles, from Station 316 three bottles, from Station 348 eight bottles. The collection from Station 316 was preserved in formalin solution; of the material collected from Station 314 and Station 348 some was preserved in formalin and some in 40 over-proof alcohol. The material from Station 355 consists of a single small incipient colony, not more than 30 mm. high, with the tubes short and crowded, and with the coenoecial substance unusually transparent.

The collection contains a number of fine pieces of colony, and a photograph of the largest of these, obtained from Station 316, is reproduced in plate 1, fig. 2. The height of this specimen is 150 mm., and the width 130 mm. It is rather more straggling, and less closely branched than the large piece obtained on the National Antarctic ("Discovery") Expedition, and figured in the reports of that expedition (17, plate 1).

Another piece, from Station 348, is interesting as showing lateral branches all in the same stage of growth, set upon a thick stem which seems to be considerably older (plate 1, fig. 1). The general appearance of the whole mass rather suggests that there has been a cessation and resumption of growth in the colony. The tubes of the lower part of the main stem are occluded and covered over with general coenoecial substance (cf. 17, p. 22), and all the tubes that are in a state of occupation by zooids seem to be of a newer growth. Whether the zooids are survivors of the original stock, or immigrants that have settled upon a "dead" coenoecium, it is difficult to say.

The third piece shown on plate 1 (fig. 3) is a small portion of a colony with rather long, thin, tongue-shaped lips to the peristomial tubes. The apex of this branch was evidently in a state of rapid growth when the specimen was dredged, as may be judged by the crowding and the delicacy of the tubes at the extremity.

A colony of *C. nigrescens* from Station 316 is represented in figs. 4 and 3 of plate 2, photographed against a light and against a dark background. In the former the black zooids lodged in their tubes show up very distinctly, and the pale grey, opalescent coenoecial substance tends to disappear, whereas in the latter photograph the coenoecial substance is very conspicuous and the zooids are visible in a few places only. These two photographs show how difficult it must be to compare adequately illustrations by different authors of specimens of *Cephalodiscus* illuminated in different ways and reproduced by different methods.

The middle of the uppermost three branches of fig. 4 shows the strange twisting of the tubes about one another which is not infrequently seen in this species. The figure of the longitudinal section of a branch of a colony of *C. nigrescens* given in the "Discovery" Expedition report (17, plate 4, fig. 10) is but a diagram, and represents all the tubes as lying strictly in a radial plane; as a matter of fact the inner ends of the tubes almost always twist about one another somewhat in the axial part of the branch, and it is only their distal halves that lie in the radial plane. The twisting of the inner portions of the tubes is shown clearly in 17, plate 3, fig. 4. In much of the material obtained by the "Terra Nova" the twisting is very pronounced, particularly in what I take to be rapidly grown branches, branches with rather short tubes, separated by very soft and perfectly clear and hyaline common coenoecial substance. Such branches are extremely fragile, and require to be handled with the greatest care.

From Station 314 were obtained some very slender branches (plate 2, fig. 5) measuring only 5 to 9 mm. across, not including the peristomial tubes. These are isolated branches, giving no indication as to the shape of the whole colony of which they formed part; a colony composed of many slender branches such as these could scarcely be brought up in the trawl in a perfect condition. It is interesting to contrast these attenuated branches with the more massive trunks that were obtained from the same Station, some of them as bulky as the piece figured in plate 2 of the "Discovery" Expedition report (17, plate 2, fig. 2).

The single small piece of *C. nigrescens* from Station 355 is of considerable interest as being what may be regarded as a recently established or young colony. It measures 30 mm. in height and 24 mm. in maximum width; the coenoecial substance is paler and more transparent and gelatinous in appearance than usual, and has not the customary grey look of the larger pieces of colony. The tubes are rather short and crowded. Only about a dozen zooids are present, although the tubes are more numerous: the probability is that some of the zooids escaped at the time of capture, or during the process of sorting and preserving the material.

The zooids of this colony are all of approximately the same age, and almost of full

size; and one may surmise that they had grown up from a group of larvae, rather than from buds. Each has several young buds of its own. The zooids have no gonads large enough to be recognised in dissected preparations; three were cut into serial sections, and one proved to possess a pair of extremely minute ovaries, while the other two had very minute gonads that were probably ovaries, but were too young to determine with certainty. Yet one of these latter zooids had a large bud possessing a pair of gonads distinctly recognisable as ovaries.

Three pieces of colony of *C. nigrescens* were dredged with *C. hodgsoni* growing upon them. They were obtained from Stations 314, 316 and 348 respectively. In the last case the *C. nigrescens* is the more bulky part of the mass, and gives support to the coenoecium of the other species; in the other two cases the branches of *C. nigrescens* are delicate. The coenoecia of both species contain zooids that were evidently alive at the time of dredging, and the specimens are interesting as showing that two different species of *Cephalodiscus* can live harmoniously together.

ZOOIDS.

As regards the bulk of the material of *C. nigrescens* collected, dredged from Stations 314, 316 and 348, it is to be noted that zooids removed from different tubes of the same colony, and all fairly well extended and apparently full-grown, vary considerably in their measurements. The measurements of six zooids taken at random from a piece from Station 348 are as follows, the first being the length in millimetres from the ends of the arms to the caecal end of the body, the second the distance from the bases of the arms to the caecal end of the body, and the third the width of the body. The constancy in the last measurement is probably due to the uniformity in the width of the coenoecial tubes within which the zooids died.

6·0—4·2—0·9	4·5—2·7—0·9
5·5—3·7—0·8	4·0—2·6—0·9
5·0—3·3—0·9	3·2—1·7—0·9

Serial sections were cut of zooids selected from representative pieces of colony from these stations, for the purpose of verifying the identification of the species, but no new observations have resulted that are worth recording.

As in the case of the zooids of *C. nigrescens* obtained by the "Discovery" (17, p. 32) the number of the arms is not absolutely constant, but seven pairs is the number found in the majority of cases.

The arms of *C. nigrescens* present considerable differences in appearance according to the mode of fixation and preservation employed. In well-preserved zooids that have been fixed either in formalin solution (5 per cent.) or in alcohol (70–75 per cent.) the black pigment is confined to certain epidermal cells, notably the tall epithelium that occurs on the neural surface of the arm—two broad black bands, with a narrow white band between them, except at the tip of the axis (*e.g.* 17, plate 5, figs. 23–24)—and in

scattered small cells along the distal halves of the tentacles of the arm. The tentacles, nevertheless, are on the whole markedly pale in comparison with the axis.

In badly preserved alcohol-fixed material there is a uniform black stain that pervades the whole of the tissues, and even spreads to a certain extent to the coenoecial substance. The arms of such material, when teased apart and examined in dilute glycerine with intense illumination, appear of a greenish brown colour in the less black parts. The colour can be reduced partially or completely by the action of diluted Eau de Javelle (1 in 30) for about two hours, but the tint of the arm after such treatment is uniform. If the action be stopped before the colour has disappeared entirely, there is no indication of the paired black band along the axis.

Why some of the alcohol-preserved material in the present collection is good and some is bad is not apparent. It may possibly be that in some cases the material had been allowed to remain so long in the trawl or in the bucket before being placed in alcohol that the zooids had died, and had begun to undergo disintegration, whereas the material that proves to be in good state of preservation was fixed with more expedition. Another possible explanation is that the strength of the alcohol used for preserving the material was not in every case maintained, that the pieces of colony, carrying naturally a large amount of sea-water, were dropped into bottles of alcohol, and closed down and brought home without changing the spirit subsequently. That this may have happened is probable from the fact that one bottle of badly fixed material, which according to the label should contain 70 per cent. alcohol (*i.e.*, about 35 over-proof), had fluid which was salt to the taste, and gave an alcohometer-reading of 32 under-proof. The fluid in another bottle of alcohol-material yielded a reading of 45 under-proof. Both of these bottles contain material the zooids of which consist of little more than a black powdery mass. The formalin-fixed material from the same station (Station 314) is in excellent preservation. Yet another possibility is that some, or all, of the material that proves to be in bad condition may have been frozen solid before it could be adequately attended to with a view to preservation.

Alcohol as a preservative for *Cephalodiscus* is not by any means to be condemned. for very good results can be obtained by its use. The method most likely to yield good fixation and preservation is to drop freshly-trawled pieces of colony into a bottle half-full of 40 over-proof alcohol (73 per cent. by weight), to pour away the fluid the next day, and fill up with 40 over-proof alcohol, and to repeat the process a fortnight later. The method, however, may be regarded as extravagant, for the fluid poured out on the second day would contain so low a percentage of alcohol as to be scarcely worth redistilling.

Alcohol, even if not stronger than 40 over-proof, causes a little shrinkage of the coenoecial substance, whereas formalin solution seems to produce no alteration in the shape of the coenoecium. One can easily test this by placing a piece of formalin-preserved colony of *C. hodgsoni* into 40 over-proof alcohol; in about ten minutes the

spines will exhibit a rather shrivelled appearance. It passes off later to a slight extent, but not entirely.

A word may here be said in favour of formalin as a preservative for *Cephalodiscus*. The fluid can be made up readily with sea-water to the required strength—5 per cent. yields good results, but 8 or 10 per cent. would probably be better if it is not proposed to open the bottle again until the end of the expedition—it penetrates well, and causes little distortion of the zooids. Although the finest histological details cannot be worked out in such material, the serial sections cut from it enable one to work out all the ordinary anatomical features, and no difficulty is experienced in staining the sections adequately if haematoxylin be used in conjunction with Orange G. A further advantage that formalin has over alcohol as a preservative is that, where it is desirable to transmit material to investigators residing in other countries than that from which the expedition started, the question of the payment of customs dues does not arise. An effort should, however, in each case be made to fix a few living zooids in appropriate hardening fluids, such as Perenyi's fluid, and corrosive-sublimate-acetic-acid-alcohol, and transfer them after a few hours to 40 over-proof alcohol.

The uniform staining of the arms in badly preserved alcohol-material is important in its bearing upon the specimens of *C. nigrescens* supposed to have been dredged on the "Erebus" and "Terror" Antarctic Expedition (19), which was most probably fixed in alcohol, the only common preservative of the time. The zooids do not show the paired black band on the arms, and there is some staining of the coenoecium. The uniform blackness of the arms puzzled me at the time when I was investigating the specimens, the coenoecial characters of which were obviously those of *C. nigrescens*; and considerable light is thrown upon the problem by the discovery, among the "Terra Nova" material, of different pieces of colony from the same station, some preserved in formalin and showing pale tentacles and a paired black band on the axis of the arms, and other pieces poorly fixed in alcohol and having the arms uniformly black throughout, and the coenoecial substance also tinted. In formalin-fixed material of *C. nigrescens* there seems never to be a staining of the coenoecial substance; thin branches are nearly hyaline and transparent, while thick pieces have at most an opalescent appearance.

A spreading of the black colour may be seen in zooids fixed in corrosive sublimate solution. While most of the material of *C. nigrescens* collected by the "Terra Nova" was fixed and preserved either in formalin solution or in alcohol, some zooids were extracted from freshly dredged colonies, and fixed in corrosive sublimate solution, and later transferred to 70 per cent. alcohol. In the arms of this latter material there is a fairly uniform dark greenish brown coloration, and the black bands of the axis are in many cases not discernible. It is as though the solid pigment-granules had been dissolved, and the resulting black fluid had imparted a uniform stain to the axis and tentacles alike.

The remarks in the preceding paragraphs refer to the appearance of the arms

examined whole under a low magnification. In serial sections certain differences due to methods of fixation are to be noticed that are not obvious in whole arms. In zooids of *C. nigrescens* fixed in Perenyi's fluid (material collected by the "Discovery") the pigmented cells of the epidermis of the neural surface of the arm are large, but not appreciably swollen; they are of a deep brown colour, nearly black, or of a rich warm brown, with scanty black specks. In material fixed in corrosive sublimate solution (material collected by the "Terra Nova") the pigmented epidermal cells appear greatly swollen and somewhat burst, and the pigment is in the form of a few scattered black spots. In material fixed in picric acid solution (material collected by the "Discovery") the cells are swollen and have a vacuolated appearance; they are clear, and show scarcely any pigment. In formalin-fixed material the cells of the neural surface of the axis, although large, are not appreciably swollen, and the pigment is abundant and jet-black, or very dark brown.

In the report of the National Antarctic ("Discovery") Expedition it is stated (**17**, p. 25) that in serial sections of material fixed in picric acid solution the pigment cells of the arm-axis are considerably swollen and not brown or black in colour, but each cell shows its one or two small black spheres as in material fixed by other methods. No mention is made, however, of the appearance of the arms examined whole. A recent examination of material of the "Discovery" Expedition that was fixed in picric acid solution and followed by alcohol, shows that the arms, axis and tentacles alike, are stained a uniform very dark brown, and the paired longitudinal black band is not visible. The epithelium of the neural surface of the axis of the arm does not appear unduly swollen, as it does in the serial sections.

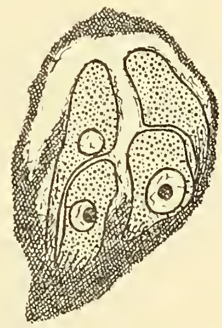
The acid seems to have the effect of dissolving and spreading the pigment in fresh material only, for the experiment was tried of soaking for 50 hours in a saturated solution of picric acid in 60 per cent. alcohol, with 2 per cent. of glacial acetic acid added, the dissociated arms of some zooids well preserved in alcohol. No visible change resulted; the two black bands remained exactly as before. Similar well-preserved arms were soaked for the same length of time in a 10 per cent. solution of glacial acetic acid, and others in an aqueous solution of corrosive sublimate, with a little acetic acid, with similar negative results.

Free ova in the material of *C. nigrescens* collected by the "Terra Nova" are similar to those previously recorded (**17**, p. 46), but are a little larger. They are mostly found in the blind end of an inhabited tube, and are usually single; rarely there are two in the same tube. Six free ova were measured, and yielded the following results:—three were $0 \cdot 8 \times 0 \cdot 7$ mm., two were $1 \cdot 0 \times 0 \cdot 6$ mm., and the last $0 \cdot 9 \times 0 \cdot 6$ mm.

The mode of extrusion of the ova from the ovary in *Cephalodiscus* is still an unsolved problem; the oviducal aperture is extremely small in comparison with the great size of the ovum, and gives no indication of capacity for great dilatation. Masterman (**15**, p. 512) has suggested that the oviducts merely serve to admit the

spermatozoa into the ovary, and that the ova are liberated by the death of the mother and the subsequent disintegration of the tissues; in other words, the ova are not laid, but survive the parental body. This view finds some confirmation from the fact that Andersson has observed the presence of spermatozoa in the ovary of *C. densus* (2, p. 85), and Gilchrist records that in *C. gilchristi* the ovaries are sometimes discharged by the rupture of the body-wall, without the death of the mother necessarily resulting; but he guards himself by a statement that the condition he is describing may have been brought about by pressure in the trawl-net (4, p. 192). In the case of *C. hodgsoni* it is by no means unusual to find zooids with the dorsal body-wall ruptured and the intestine rent and partially evaginated, but this is a condition which one rather attributes to the violent contraction of the body on coming into contact with the fixing fluid.

That in the case of *C. nigrescens* the eggs are definitely laid is probable from the frequency with which, in material obtained on the British Antarctic Expedition, a free ovum is found among the buds at the blind end of a tube inhabited by a female that still possesses two perfect ovaries. There can scarcely be any doubt in such cases that the free ovum found was produced by the zooid occupying the tube.



Text-fig. 3.—*Cephalodiscus nigrescens*, transverse section through the oviducal end of the ovary, showing unilateral proliferation of the ovicells. (× 230.)

In *C. nigrescens* the ova bulge into the cavity of the ovary (text-fig. 3), as in *C. solidus* (2, plate 7, fig. 64), and do not lie externally to the cavity, as they do in *C. hodgsoni* (= *inaequatus*; 2, fig. 63). The character as a means of discriminating species is not very satisfactory, for in the broadest part of the ovary the ova are so closely compacted that either no cavity is seen, or one cannot satisfactorily decide whether the cavity is the true lumen of the ovary or an artefact. It is only near the external opening of the ovary, where the ova are comparatively small, that the point can be settled. In the section represented in text-fig. 3 the ova are seen to be proliferated from one side of the oviduct (the side nearest the shield), and they bulge into the cavity of the ovary, much in the same way as is figured for *C. solidus* by Andersson (2, plate 7, fig. 64).

CEPHALODISCUS DENSUS, Andersson.

Cephalodiscus (*Orthoecus*) *densus*, Andersson.—For diagnosis, references and list of recorded specimens, see page 75.

MATERIAL COLLECTED.

Material of *C. densus* was obtained from McMurdo Sound, in Ross Sea, at Stations 314, 316, 339, 355 and 356, and from off Coulman Island at Station 295. For details as to depths and dates, and the precise positions of these Stations, see page 12.

From each of the Stations 314, 316, 355 and 356 one bottleful of *C. densus* was dredged; the collection from Station 339 is contained in two bottles, and that from Station 295 in three bottles. The material from Station 314 is preserved in alcohol, as also is a part of the collection from Station 295. From the material obtained at Station 339 two living zooids were extracted by Mr. D. G. Lillie, and fixed in corrosive sublimate solution, and subsequently transferred to alcohol (plate 5, figs. 7 and 8). The rest of the collection was fixed and preserved in formalin solution.

The finest specimen collected is a large, complete, cake-like, nearly spherical colony, measuring 100 mm. in height, and 130 mm. across (plate 3, fig. 6). This was obtained from Station 356. The specimen is extremely difficult to handle, for the coenoecial substance is very soft and spongy in consistency, and when the mass is lifted out of the formalin solution, even with the mouths of the tubes uppermost, the fluid drains out, and the colony shrinks to about a third of its former bulk. On putting the specimen back again into the fluid it rapidly regains its original size.

The base is comparatively smooth, and was probably resting upon a level muddy bottom, from which it was easily lifted by the trawl. The substance of the base is uniform, and shows no tubes, but the probability is that the tubes come to within a few millimetres of the actual under-surface. The colony has not been bisected, and so the course of the tubes within it can only be conjectured, but from an examination of other specimens in the collection it is probable that the tubes that reach the summit extend down vertically, and end blindly near the base, and are thus about 90 mm. in length. The other tubes are directed more or less obliquely, and those in the lowest parts, above the edge of the base, are nearly horizontally disposed. These tubes, judging from other specimens, would not be more than 30 or 40 mm. in length.

The longest tubes actually traced out, in specimens other than that mentioned in the preceding paragraph, are 70 mm. in length. The shortest tubes found are 15 mm. long, but there are in all probability tubes shorter than this; indeed, there is no reason why tubes should not occur as short as 5 mm., for a newly established zooid would not be likely in the first instance to secrete a tube much longer than its own body. The width of the cavity of the tubes is mostly 1·0 to 1·2 mm.; near the ostium the width is usually a little greater than in the rest of the tube. The width of the cavity agrees with that of authentic material of *C. densus* examined by Andersson and now at the British Museum (Natural History), and it is evident, from the fact that Andersson states the "Durchmesser" of the tubes of *C. densus* to be 1·5 mm., that of *C. rarus* 1·5 mm., occasionally up to 2·0 mm., and that of *C. solidus* slightly over 2·0 mm. (2, pp. 11–13), that he is quoting the *external* diameter of the free portions of the tubes. The width of the cavity I find to be less liable to fluctuation than the external diameter, and consequently better suited for systematic purposes.

There are in the collection many pieces such as might result from the tearing up of a complete colony like that shown in plate 3, fig. 6, pieces about 70 or 80 mm. in

height and 50 to 80 mm. in width, with long tubes disposed in more or less parallel series, and loosely bound together by a very soft, spongy, common coenoecial substance that continues for 5, 10 or 15 mm. beyond the blind ends of the tubes, and extends to within 10 or 20 mm. of the ostia, thus leaving freely projecting lengths of tube which in the case of species of *Idiothecia* would be termed peristomial tubes. From the characters both of the coenoecium and of the zooids there is no question that these pieces, like the complete colony, belong to *C.* (*O.*) *densus* Andersson (2, p. 12).

In the same bottles with such pieces, and in several instances actually continuous with them, are pieces such as those shown in plate 3, figs. 2, 4 and 5, in which the common coenoecial substance is less abundant, and although it binds together the basal ends of the tubes, leaves a much greater extent of the ostial ends of the tubes free. The tubes are less obviously in parallel arrangement, and the ostial ends are extremely delicate, and give one the impression of being but recently formed. One is thus disposed to regard such pieces as constituting the rapidly growing edges of large cake-like colonies, or outlying offsets from them, and to assume that if they had been allowed to remain undisturbed, the intervals between the tubes would have been gradually closed up by common coenoecial substance, and that the margins of the ostia would have become thicker and darker, more like the middle parts of the tubes, and that later, when growth became less active, the colony would resemble that shown in fig. 6.

The piece shown in fig. 1 of plate 3 has even less union between the tubes than those reproduced in figs. 2, 4 and 5, and the tubes are still more irregular; and in fig. 3 is shown a piece of colony in which the tubes are extremely irregular in their course, rambling and straggling, and only united at their basal ends. This last piece, and other similar pieces, of which there are several, I am unable to distinguish from *C. rarus* Andersson (2, p. 12).

From a study of Andersson's published descriptions, and a critical examination of authentic material of *C. densus* and *C. rarus* obtained on the Swedish South-Polar Expedition, and received by the British Museum (Natural History) from the Stockholm Museum in exchange for other specimens, I am convinced that Andersson's two species stand in exactly the same relation to one another as the pieces of "Terra Nova" material represented in figs. 6 and 3 of plate 3. Andersson bases his distinction between the two species almost entirely upon the characters of the coenoecium, and such differences as he finds between the zooids of the two species (*e.g.*, the thickened epidermis of the axis of the arms, discussed on p. 22 of the present report) are such as might well occur within the limits of the same species.

Assuming, as one is justified in doing, that a young, newly established colony is composed of short tubes, scarcely longer than the zooids themselves, the probabilities are that the tubes, as they are increased in length, may adopt a rambling course, being unimpeded by anything in the immediate vicinity, and the result will be a straggling

set of tubes such as those in fig. 3 of plate 3. But as the buds of the pioneer zooids separate off and construct tubes of their own, they incommode the earlier zooids, and also one another; and since the number of tubes is still increasing, the oldest tubes, in the middle of the mass, will be made longer and straighter and more closely set, and intermediate, soft, coenoecial substance will be secreted to fill up the intervals between the tubes. Thus the colony ultimately may come to have the form of a hemisphere, or a cake with the edges thinner than the middle part. The middle would consist of long, straight, almost parallel tubes (except in their lowest, first-formed parts), and the edges of the cake would be composed of shorter, less straight, and more radiating tubes, less closely cemented together.

Arguing along these lines, one may draw a distinction between the coenoecia of *Orthoecus* and *Idiothecia* as regards their modes of growth: for in *Idiothecia* the youngest zooids and the shortest tubes are to be found at the free ends of the branches, whereas in *Orthoecus* the youngest zooids and the shortest tubes are found around the margin of the mass, and the colony in consequence does not adopt a branching form. One may describe the mode of growth of the colony of *Idiothecia* as apical, and that of *Orthoecus* as peripheral.

With such a complete gradation of specimens between the *rarus* form of *Orthoecus* (fig. 3) and the *densus* form (fig. 6) as is now available for study in the collection made by the "Terra Nova," it becomes clear that one of the two specific names should disappear. Since on page 12 of Andersson's monograph (2) the diagnosis of *C. densus* precedes that of *C. rarus*, I adopt the former name to include the latter; so that *C. rarus* is in the present report regarded as a synonym of *C. densus*. The whole of the material of *Orthoecus* collected by the "Terra Nova" I consider to be *C. densus*.

Incidentally it may be mentioned that if *C. rarus* becomes a synonym of *C. densus*, it is doubtful whether *C. anderssoni* Gravier (6 and 8) can stand as a distinct species. The characters of the coenoecium are not very different from those of the specimens of *Orthoecus* obtained by the "Terra Nova," the prevailing feature of Gravier's species being apparently a grouping of the tubes in clumps of four or more, which stand out more or less distinctly from the other clumps (*infra*, p. 76). The zooids are stated to be in a poor state of preservation, and to have a certain pigmentation of the stalk and of the shield. The number of arms in *C. anderssoni* is not mentioned, but buds are said to have arms up to six pairs.

Although there is so close a resemblance between the coenoecia of the forms that have been described by Andersson as *C. densus* and *C. rarus*, and by Gravier as *C. anderssoni*, the species termed *C. solidus* by Andersson (2, p. 11) is markedly distinct from these. The common coenoecial substance of *C. densus* is extremely soft and spongy, and liable to disintegration, whereas that of *C. solidus* is firmer and more gelatinous, rather resembling that of *C. nigrescens* in its consistency. A piece of colony of *C. densus* shaken up violently in a bottle half full of water would separate into its

individual tubes, but a piece of *C. solidus* similarly treated would break across the tubes almost as readily as along them. The thick peristomial lip of the tube of *C. solidus* finds no equivalent in *C. densus*, and the blackish colour of the zooids marks them off from those of the latter species.

The entanglement and inclusion of diatoms and sand-grains in the softer material of the coenoecium, to which Andersson alludes (2), is a character which one comes to regard with suspicion. A study of specimens of *C. nigrescens* leads to the conclusion that if foreign particles are abundant they will in all probability be included in the secreted coenoecial substance; and although the specific name *agglutinans* was applied to the form of *Cephalodiscus* dredged by the "Scotia" on the Scottish National Antarctic Expedition (11) because the material collected includes so much in the way of shell-fragments, yet this inclusion may be purely local, and it is quite possible that in other, more rocky, parts of the ocean-floor the zooids of the species might build up a perfectly clear and transparent coenoecium. This question is dealt with in more detail in the section on *C. evansi* (p. 27).

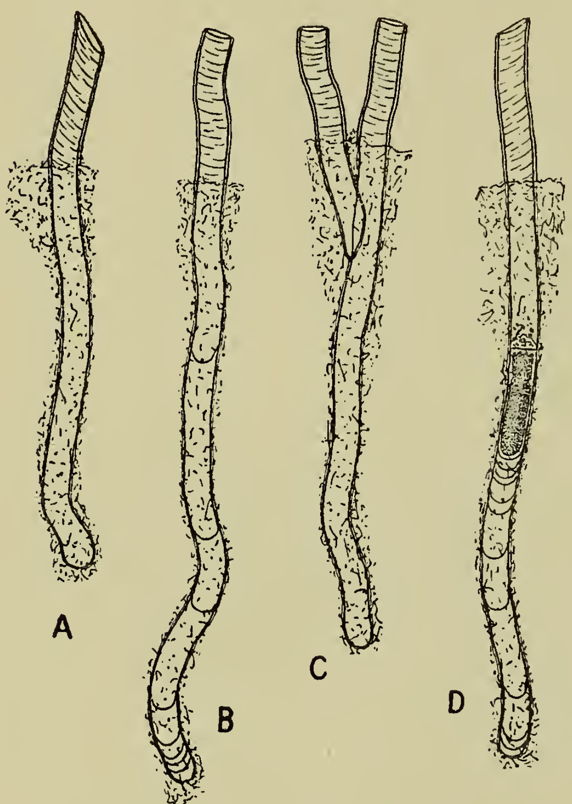
The part of the material from Station 295 that was fixed in alcohol—the other two bottles contain formalin—consists of half a dozen fragments measuring 45 to 60 mm. in height and 25 to 50 mm. in width, evidently pieces broken from a large mass. The tubes are fairly straight, and are bound loosely together by soft coenoecial substance except for their uppermost 8 or 10 mm. The freely projecting parts are of a darker tint than the embedded parts of the tubes, the reverse of what is found in some other portions of material of this species (*e.g.*, plate 3, figs. 1–5). One peculiarity of this material is the frequent obliquity of the ostium and the sudden widening of the tube at its free end (text-fig. 4, A). A similar obliquity of the free end of the tube has been noted by Gravier in the material that he describes as *C. anderssoni* (6); and it is also seen in some of the tubes of Andersson's fig. 6 of *C. rarus* (2), although not in fig. 5. In Gravier's material it is the laterally placed tubes that end in this manner. It is probable, therefore, that the pieces of *C. densus* from Station 295 are lateral fragments of a very large cake-like colony. The longest tubes dissected out measure about 55 or 60 mm., and have an average internal diameter of 1·1 mm. Curved septa occur in the basal parts of the tubes (text-fig. 4, D).

In certain pieces of colony there is a tendency for the tubes to exhibit externally projecting flanges around the ostium, and also lower down the tube. A few of this kind are shown in fig. 6 of plate 5. They indicate what may be interpreted as a slow rate of growth of the tube, whereas the smooth, colourless terminal portions of tubes, seen in figs. 1–5 of plate 3, represent a rapid lengthening of the tube. A few tubes with flanged mouths are to be seen in the left-hand part of fig. 6 of plate 3.

In the pieces of colony in which the upper parts of the tubes are delicate and colourless (figs. 1–5, plate 3), the basal parts are yellow or brown in colour, tough, and with a distinct sheen, or sometimes an iridescent glint; the same holds good in the

case of long parallel tubes such as belong, one assumes, to the middle of a large cake-like colony.

One tube dissected out is of interest in that it shows, applied to its side, a much shorter tube adhering by its basal, blind end (text-fig. 4, C). The interpretation of this association, I take it, is that the part of the main tube where the short tube is attached was at the time not enclosed in common coenoecial substance as it is now, and a young zooid settled upon the side and began constructing its own tube. As the colony continued to enlarge, both of the tubes were lengthened at their ostial ends at about the same rate, and common coenoecial substance was deposited higher and higher up between and around the tubes, until the present level was reached.



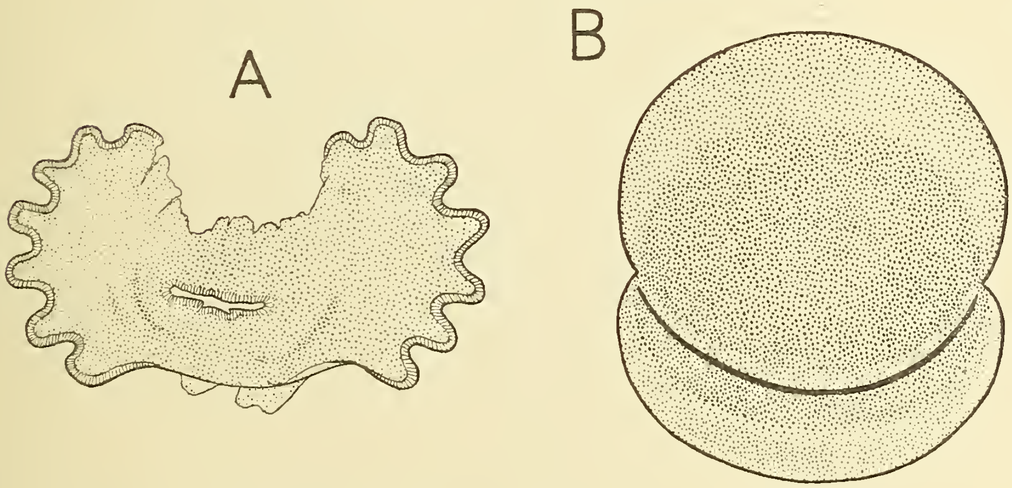
Text-fig. 4.—*C. densus*, tubes dissected out from the colony. (× 3⅓.) The tubes are rendered diagrammatically, and are drawn shorter than they should be in proportion to their width. A—a tube with a bulbous blind end, and an oblique ostium; Station 295. B—a tube with a number of septa, the highest being more than halfway up; the ostium is square to the axis of the tube; Station 316. C—a young tube applied to the side of the upper portion of an older tube; Station 316. D—a tube with a zooid that has sealed itself in by means of a flat transverse septum; numerous curved septa occur in the lower part of the tube; the ostium is moderately oblique; Station 295.

Another tube encountered is of interest in that it contains what appears to be a "dormant" zooid (text-fig. 4, D). The zooid occupies a position about halfway up the tube, and rests upon the uppermost of a series of curved septa. Immediately above the arms of the zooid is a thin, flat septum, and upon this rest a number of free sand-grains. In the case of partially sealed-up tubes of colonies of *C. solidus* it has been suggested (21) that the material when brought up in the trawl was left for some time before being dropped into the preservative solution, and the zooids, for their own protection, rapidly secreted a loose operculum of coenoecial substance at the mouth of the tube. In the present instance the suggestion does not seem to apply, for the closing partition is thin, like the curved septa in the basal end of the tube, and the neighbouring tubes of the piece of material in which this one was found do not exhibit similar occluding septa.

ZOOIDS.

The zooids vary a good deal in size, and the wide range may be judged from the following measurements. The first is the length in millimetres from the free ends of the arms to the caecal end of the body, the second the length from the bases of the arms to the end of the body, and the third is the width of the body.

Station 295	6·0 — 3·2 — 0·8
	4·5 — 2·4 — 0·7
	3·7 — 2·0 — 0·8
	3·5 — 1·9 — 0·9
Station 316	7·4 — 4·3 — 0·9
	7·0 — 5·0 — 0·9
	6·2 — 3·9 — 0·8
	4·8 — 3·0 — 0·9
Station 339	5·5 — 3·5 — 0·9
	5·0 — 3·4 — 1·0



TEXT-FIG. 5.—*Cephalodiscus densus;* Station 339; A, oral lamella; B, shield; × 48.

On an average based upon observations on Swedish Expedition specimens, Australasian Expedition specimens (21), and "Terra Nova" specimens, one may quote the measurements for zooids of *C. densus* as:—4 to 7—2 to 4—0·8 to 1·0 mm. The general aspect of the zooids may be seen from figs. 7 and 8 of plate 5, which are reproductions of photographs of zooids removed from their tubes alive, and specially killed in corrosive sublimate solution.

The colour of the zooids is in some cases distinctly orange or brown, but in most it is ochreous, or pale brown, or greyish white.

The shield of *C. densus* differs in no important respects from those of other species of *Cephalodiscus.* When fairly well expanded it presents a roughly circular outline, and the mean of the antero-posterior and the lateral diameters is about 1·1 mm. When dissected off and examined by transmitted light it shows a dark area in the

middle of the main or anterior lobe, and a rather dark band in the posterior lobe, touching the red line. The marginal part of the posterior lobe is thinner and more transparent than the marginal part of the main lobe (text-fig. 5, B). The lateral indentations are less pronounced than those exhibited by *C. nigrescens*, *C. hodgsoni* and *C. dodecalophus* (17, text-fig. 9, C, p. 27, and text-fig. 17, E and F, p. 54); but this is largely a question of the degree of contraction in which the zooid died; the smoothness of outline shown in text-fig. 5 is only to be seen in zooids that have died in a flaccid condition. The lateral notches are frequently better marked in buds than in adults (see text-fig. 8, F, p. 47).

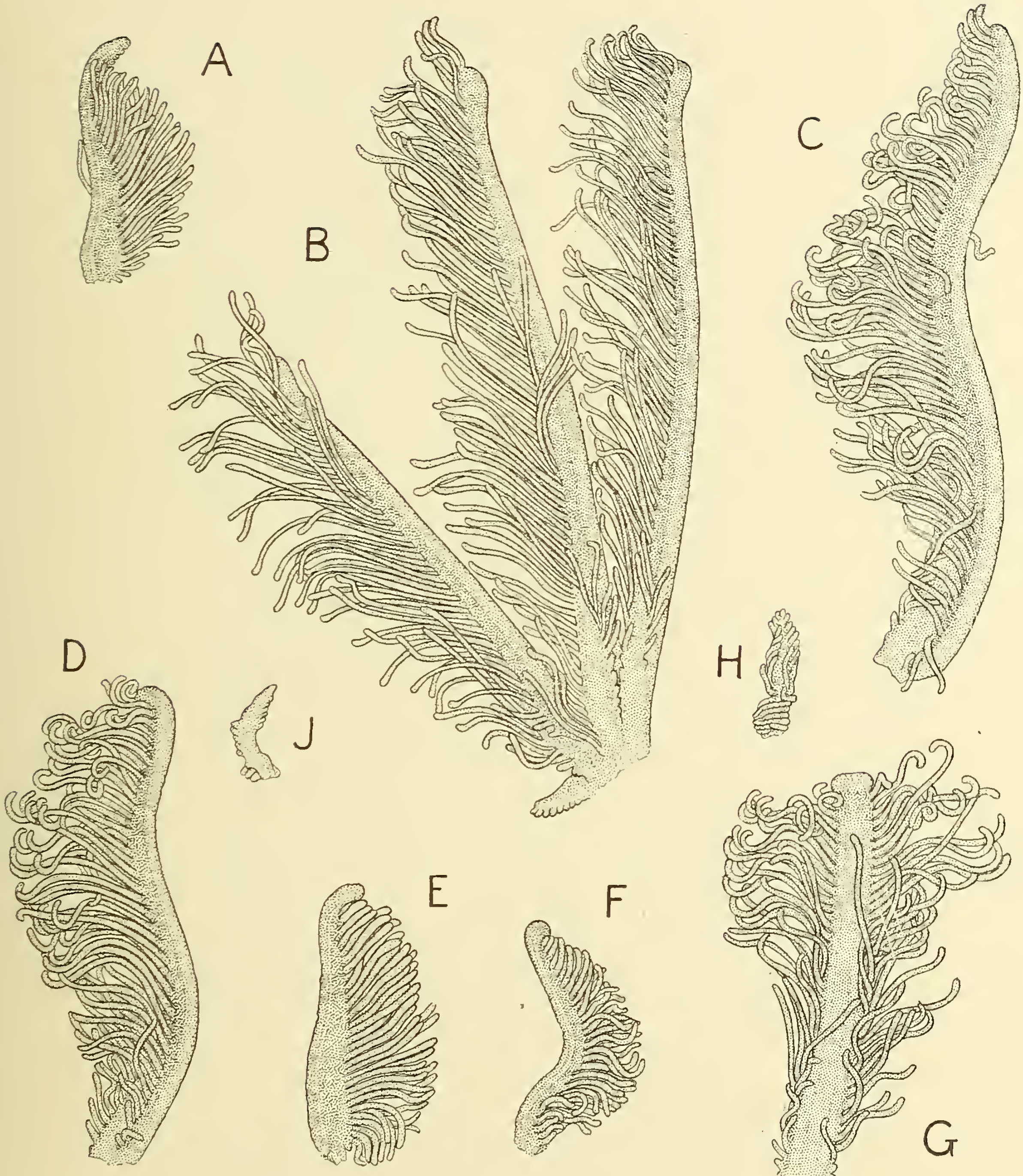
The oral lamella varies considerably in its outline in different zooids. In some, presumably those that have died in a relaxed condition, the margin is even, with a very slight wavy curve; in others (text-fig. 5, A) the seven, rarely eight, sinuosities or scallopings of each lateral lobe are very pronounced. The figured specimen was dissected from the zooid shown in plate 5, fig. 7.

The arms, when in a state of full extension (text-fig. 6, B and C), measure about 3 mm. If dissected apart, they tend to lie upon their sides on the slide, but occasionally one finds an arm with the two rows of tentacles lying in the same plane (G). The axis of the arm does not terminate in an end-swelling with refractive beads, so characteristic a feature in *C. dodecalophus* and *C. hodgsoni*, and it is necessary to avoid drawing a false conclusion from moderately contracted arms, such as F, which have a slightly enlarged, incurved tip to the axis. Such extremities have no highly refracting beads, and they occur singly, not more than one, for instance, in the set of sixteen arms of a zooid; most zooids have none at all. Similar occasional enlarged terminations are met with in *C. gilchristi* (16, p. 184, and text-fig. 2, B), and something approaching them is sometimes found in *C. nigrescens* (17, plate 5, fig. 26) and *C. agglutinans* (11, p. 549, text-fig. 4, C).

The arms are usually eight pairs in number, but two zooids were found with seventeen arms, and several with fewer than sixteen. Interest attaches to some of these latter cases, for they occasionally show diminutive, or arrested arms, not more advanced in their development than those that occur in late buds, such as the developing arms shown in text-fig. 8, J, K, L, p. 47. Two of these arrested arms are represented in text-fig. 6, H and J, and another in the lower part of figure B, showing its size in relation to the full-grown arms.

The alimentary canal does not differ materially from that of other long-bodied species, such as *C. nigrescens*. The stomach extends nearly to the end of the trunk; the gastric caecum projects so far forwards between the pharynx and intestine that its extremity is visible in transverse sections that include the gill-slits.

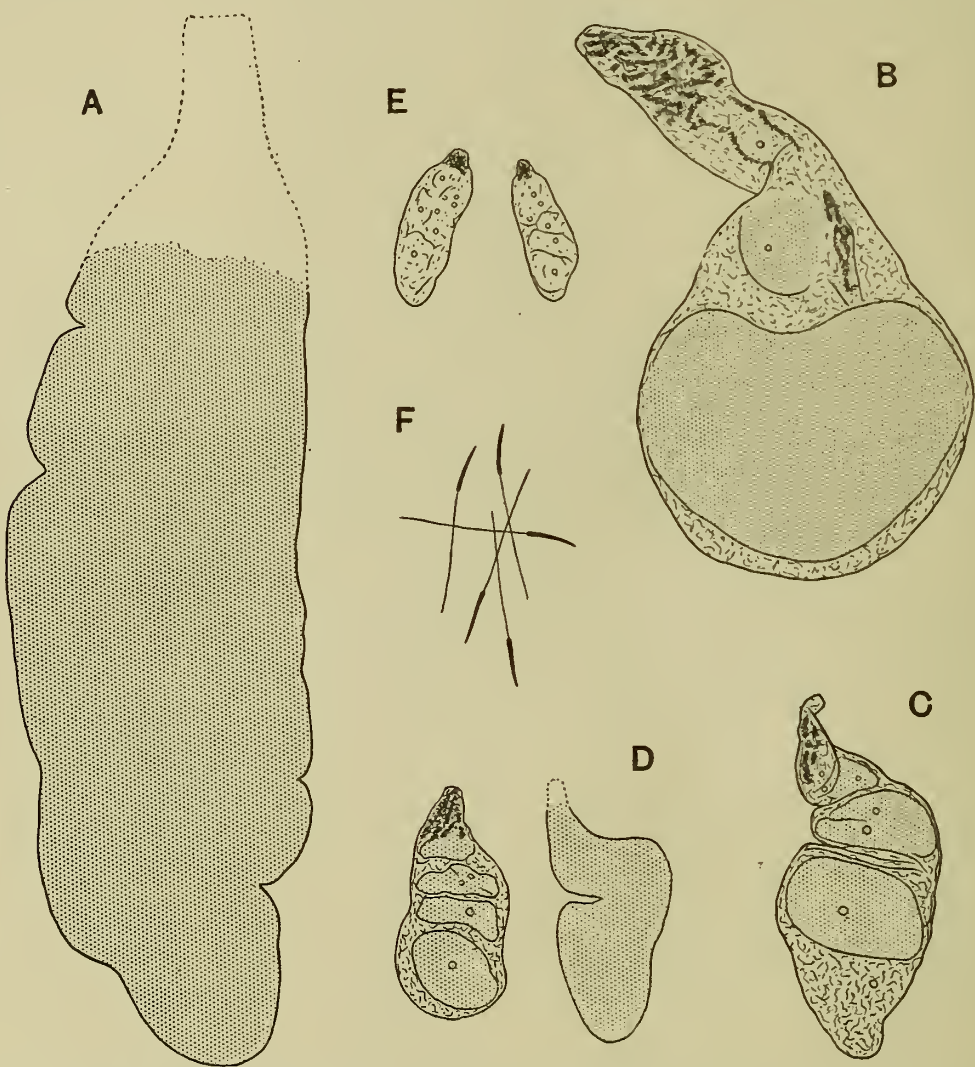
Male and female zooids and hermaphrodites (with one ovary and one testis) occur in different tubes of the same colony. The testes, although of the long, as opposed to the globular variety, are not so long as those of *C. nigrescens* and *C. solidus*. Perhaps "elongate pyriform" would describe them better. The total length is about



TEXT-FIG. 6.—Arms of *Cephalodiscus densus*; × 35. **A**, a contracted arm, with short tentacles near the extremity. **B**, three arms in a state of full extension, and another very diminutive arm at their base. **C** and **D**, typical examples of extended and moderately extended arms. **E**, a contracted arm, differing from **A** in having longer tentacles near the extremity. **F**, an arm with a slightly enlarged and incurved tip simulating an "end-swelling." **G**, an arm seen in flat view. **H** and **J**, arrested arms, very small arms occurring sporadically among arms of full size; another is shown in the lower part of **B**.

four times the width (text-fig. 7, A), sometimes five or six times, but immature testes are relatively short (D). The spermatozoa (text-fig. 7, F) are very similar to those of *C. gilchristi* (16, text-fig. 5, J, p. 189); the tail is two and a half times as long as the head. The head is rather long (0·005 mm.), and tapers to a point.

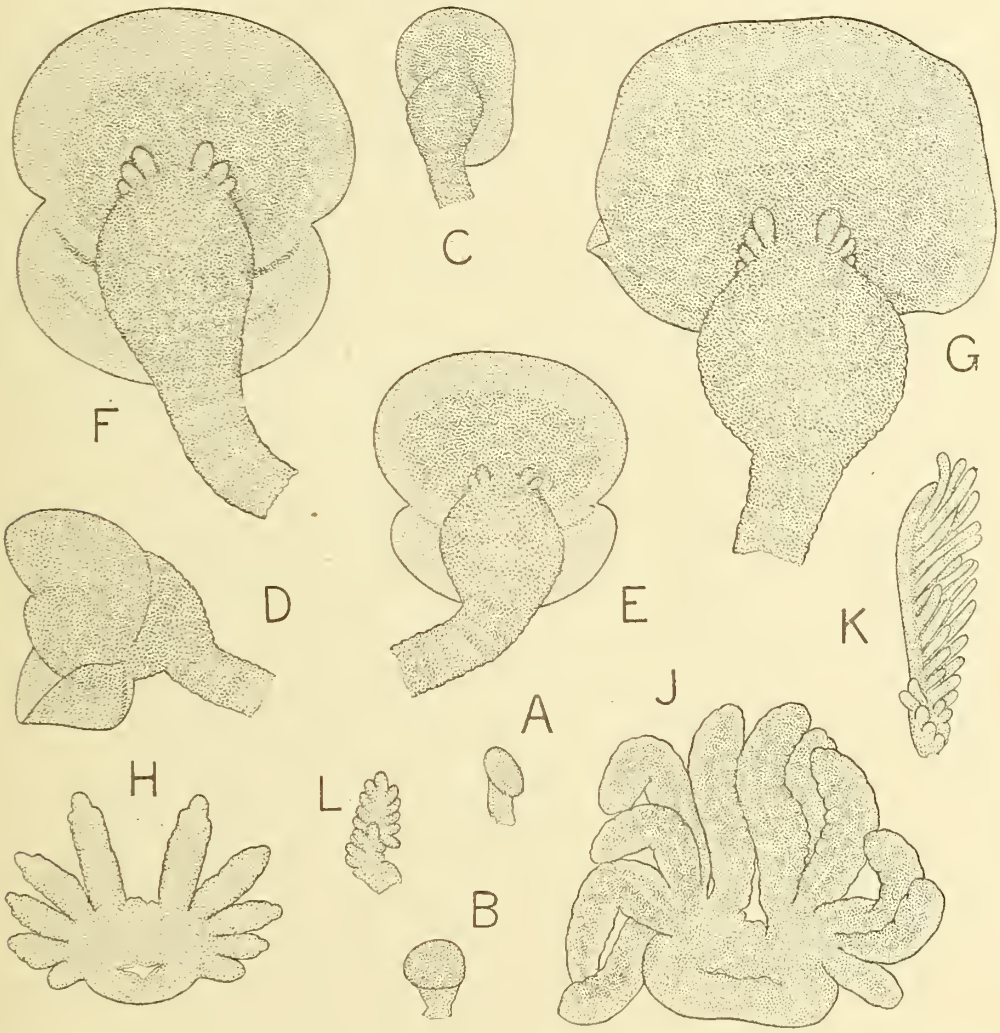
The ovaries are large in mature zooids (text-fig. 7, B), and show one, sometimes two, large, heavily yolked ova in the posterior end. The oviducal end has the



TEXT-FIG. 7.—Gonads of *Cephalodiscus densus*. A and B, testis and ovary of the same zooid. C, a young ovary. D, ovary and testis of a full-sized but immature zooid. E, the two ovaries of a full-sized but immature zooid. F, ripe spermatozoa. Fig. F is × 1320, the other figures are × 66.

usual irregular patches of red pigment. Young ovaries appear as shown in figures C and D, very young ovaries as in E. When the gonads are smaller than this—figures A–E are drawn to the same scale—it is not possible to decide in dissected preparations whether they are ovaries or testes, and recourse must be had to the study of serial sections.

The liberated ova found in the tubes of the colony are free, not attached by a stalk; they measure about 0·8 by 0·7 mm. As a rule not more than two ova occur in one tube, but in one instance, from Station 316, three ova were found in a tube that was inhabited by a hermaphrodite individual, the ovary and testis of which were both large, and apparently equally mature.



TEXT-FIG. 8. *Cephalodiscus densus*; buds; × 55. A, a very young bud, side view. B, a slightly older bud, ventral view. C, a bud just before the appearance of the red line of the shield, dorsal view. D, an older bud, in side view, with the posterior lobe of the shield turned forward. E, a bud of about the same age, dorsal view, showing the first two pairs of arms. F, an older bud, with three pairs of arms developing. G, a bud with the fourth pair of arms appearing; the posterior lobe of the shield is turned forward, as in D. H, the oral lamella and the five pairs of arms of an older bud. J, a similar preparation from a bud with six pairs of arms—one arm on the left side of the figure is concealed from view. K, the largest arm of an older bud possessing thirteen arms. L, another arm of the same bud.

The part of the material from Station 295 that was fixed in alcohol contains zooids in an excellent state of preservation, and these were studied in detail by means

of serial sections. Sections cut parallel to the sagittal plane show that the notochord has a slight but fairly constant sigmoid flexure, the heart being attached at one of the concavities, at about one-fourth of the length from the anterior end. The pericardium extends some little distance beyond the extremity. The longest of six notochords measured is 0·33 mm., and the shortest 0·23 mm. in length; these figures agree tolerably well with those of Andersson (2, p. 59), who gives the length in *C. rarus* and *C. densus* respectively as 0·28 and 0·24 mm. The extremity of the notochord is not appreciably swollen (cf. *Demiothecia*), nor is it sharply bent (cf. *C. gilchristi*, 16, p. 186, text-fig. 3). The anterior two-thirds of the notochord is in longitudinal sections well defined and easy to follow, but the hindermost part is difficult to trace with precision.

The longest notochords are also the thickest. There is a considerable range of variation in the thickness of the same notochord at different points, and a transverse section through the middle of the length of a notochord varies in shape in different zooids from a circle to a dorsoventrally compressed ellipse. The mean of the horizontal and vertical diameters of such a section stands, however, fairly constant at somewhere between 0·040 and 0·045 mm. (cf. 2, p. 62).

BUDS.

The buds on each zooid are numerous, commonly eight, rarely as few as five, occasionally as many as thirteen or fourteen. In the late development of the arms of the buds the species resembles *C. nigrescens* (18, text-fig. 6, p. 236), *C. agglutinans* (11, text-fig. 5, p. 555), *C. gilchristi* (18, text-fig. 9, p. 243) and *C. solidus* (21, text-fig. 3), and differs from the various species of *Demiothecia*—*e.g. C. dodecalophus* (18, text-fig. 4, p. 231) and *C. hodgsoni* (18, text-fig. 2, p. 225). In text-fig. 8 are given illustrations of buds of *C. densus* in a graded series, from those without any traces of arms (A—C) to one showing the sixth pair in process of development (J). The tentacles of the arms make their first appearance when the bud has five pairs of arms (H.) The oldest bud found had a series of thirteen arms, the largest of which is shown in figure K.

CEPHALODISCUS HODGSONI, Ridewood.

Cephalodiscus (*Demiothecia*) *hodgsoni*, Ridewood.—For diagnosis, references and list of recorded specimens, see page 67.

MATERIAL COLLECTED.

Material of *C. hodgsoni* was obtained from Stations 314, 316, 338, 339, 340, 348 and 355, all of which are in McMurdo Sound, in Ross Sea. For details as to depths and dates, and the precise positions of these Stations, see page 12. From each of the

Stations 316, 338 and 340 one bottleful of material was dredged ; the collection from Station 314 occupies seven bottles, that from Station 348 seven bottles, that from Station 339 five bottles, and that from Station 355 five bottles. Six of the twenty-seven bottles contain alcohol, the rest formalin solution. Some loose zooids from colonies collected at Station 314 were fixed in corrosive sublimate solution, and subsequently transferred to alcohol.

The finest colony of the whole collection is one which was obtained from Station 355. As now mounted on a sheet of glass in a flat-fronted bottle for exhibition in the public galleries of the British Museum (Natural History), it measures 250 mm. in height, and 150 mm. in greatest width. It is mostly of a rich amber colour, but the extremities of the branches are pale and nearly transparent. The coenoecium contains very few zooids.

Illustrations of selected pieces of colony of *C. hodgsoni* are given in plate 4, figs. 1–3, and plate 5, figs. 1–5. Comparing fig. 1 with figs. 2 and 3 of plate 4, there is to be seen a marked difference in general "habit" or "facies" which might easily influence one into regarding the specimens as belonging to different species, and it is only after prolonged and careful study of the whole of the material of *Demiothecia* collected by the "Terra Nova" that I have come to the conclusion that there is no specific difference between them, and this in spite of the fact that one of the forms has, in a majority of the zooids, twelve arms, whereas in zooids of the other form the number is more commonly ten.

The specimens reproduced in plate 4 are specially selected because they show the differences between the two forms in a most marked degree—they are extreme cases ; but while in the majority of instances there is not much difficulty in deciding to which form any particular specimen belongs, there are a few cases which, in the features of the coenoecium, are strictly intermediate in character, and there are other pieces of colony which exhibit the distinguishing features of the one form in certain parts and those of the other form in other parts. The pieces of intermediate character and those of composite character are scarce, but they are sufficient to prevent any hasty division of the material into separate species. The pieces in question have no zooids, and so appeal cannot be made to the number of the arms.

Since cases are known of two distinct species of *Cephalodiscus* growing in continuity (*C. hodgsoni* and *C. nigrescens*, page 33), the possibility is not excluded that the composite pieces referred to above were being built up simultaneously by the zooids of two species of *Demiothecia* living in harmony ; but I do not believe this is a correct explanation. In any case, it would not account for the origin of pieces of colony of intermediate character. For purposes of reference I propose to allude to the form exemplified in fig. 1 of plate 4 as Form A, and that illustrated by figs. 2 and 3 as Form B.

Form A is more common than Form B ; it was obtained from the seven Stations 314, 316, 338, 339, 340, 348 and 355, and Form B from Stations 314, 339

and 348. It will be noticed that Form B was not obtained from any station that did not yield Form A.

Even within the limits of Form A the diversity of coenoecial characters is very considerable. In figs. 3, 4 and 5 of plate 5 are shown three rather extreme instances. The piece shown in fig. 5 has spines that are much more thickly set and crowded than those of the large piece shown in fig. 1 of plate 4; and, judging from the delicacy of the spines at the upper extremity, active growth was proceeding there when the specimen was dredged. The lower part of the specimen is of a deep amber colour, the upper part is pale and transparent.

Fig. 3 of plate 5 illustrates a piece of colony that is much branched and straggling, without a definite main axis, and with long, stiff spines; the whole is of a deep amber colour, and there is no evidence that growth of the branches was taking place at the time of capture. The piece shown in fig. 4, however, while exhibiting the same general type of branching as that shown in fig. 3, is smaller, extremely pale, and transparent, and is what I consider to be a rapidly proliferating part of a colony. These three pieces have been selected for figuring because they exhibit the extreme features mentioned above. Whatever doubts I may have had regarding the propriety of including Forms A and B within the same species, I have no hesitation in concluding that these three pieces are specifically identical, and that they belong to Form A of the species. The amount of material collected and now available for study is large, and the occurrence within it of every intermediate gradation of coenoecial facies between the extremes here illustrated warrants the grouping together of the specimens within the same species. Nor are any differences that could be regarded as justifying a splitting of the species to be observed in the zooids of the specimens. While I have not seen in one and the same colony the features represented severally by figs. 3, 4 and 5, it is not difficult from the abundant material available to pick out colonies which in different parts are like figs. 3 and 4, or like figs. 4 and 5, or like figs. 3 and 5. The specimens shown in figs. 3 and 4 were obtained from Station 348; that shown in fig. 5 is from Station 355.

In fig. 2 of plate 5 is shown a piece of Form A from Station 338 differing from that represented in fig. 5 in being rather more stoutly built, of a still darker amber colour, and without the indications of growth at the apex. In general aspect it is strikingly different from the more straggling piece shown in fig. 1 of plate 4. In marked contrast with it is another (fig. 1, plate 5), from Station 355, exhibiting a very definite main axis, with less closely set spines, and with two rapidly growing regions, one at the apex and one about halfway down. This piece is clearly a piece of Form A, but on comparison with fig. 3 of plate 4 it will be noticed how the uppermost part of it tends to approach Form B.

Of the three pieces of colony of *C. hodgsoni* referred to on page 33 as growing in continuity with the coenoecium of *C. nigrescens*, that from Station 348 and that from Station 314 are of Form B, whereas that from Station 316 is of Form A.

FORMS A AND B OF *C. HODGSONI.*

An attempt to describe differences so intangible, subtle and elusive as those subsisting between the Forms A and B of *C. hodgsoni* will necessarily appear unsatisfactory and unconvincing: the statements must take the form of broad generalisations, followed immediately by qualifications that rob them of a large proportion of their significance. The generalisations are essential if any distinction at all is to be drawn between the two Forms, and the qualifications are necessary to prevent the several distinctions from being regarded as arbitrary and absolute.

Speaking in very general terms, one may say that the coenoecium of Form B is constructed on a larger scale than that of Form A; the inhabited cavities are larger, and the spines, particularly the terminal spines, are longer and thicker, and exhibit less forking; the terminal ostia are larger and more funnel-shaped, and lateral ostia are less frequent.

In Form B there is rather less difference in colour between the apical and basal parts of the colony than in Form A. The rich amber tint of the older parts of the coenoecium of Form A does not appear in any of the specimens of Form B in the collection; the older parts of the colony of the latter are dull brown, while the most recently secreted parts are almost colourless.

The inhabited cavities in the coenoecium are on the whole rather wider in Form B than in Form A. Measurements of two typical pieces taken from the same bottle of material dredged at Station 348 show that in Form B the cavity has an average diameter of 4·5 mm.; in some places, however, the width is as large as 6 mm., and in others as small as 2·5 mm. In Form A the average diameter of the cavity of the coenoecium is 3 mm., but in some places the width is as great as 5 mm., and in others as small as 1·5 mm.

In Form B the ostia are mostly terminal, funnel-shaped and large, measuring 2·5 to 3·5 mm. by about 1·5 to 2 mm.; there are other ostia at the ends of short side branches, and these are terminal in a sense; the few really lateral ostia that occur, situated on the side of the axial part of the colony, are smaller, sometimes as small as 1·6 by 1·4 mm. With the terminal ostia are associated two or three, sometimes four spines. In Form A the ostia are more uniform in size, and measure about 1·5 to 2 mm. by 1·0 to 1·5 mm.; they are much more commonly lateral than terminal. Newly formed ostia measure about 3 by 2 mm., but they are subject to reduction in size later. In both Forms the terminal ostia are difficult to measure by reason of the sloping spines that support the sides.

In the "Discovery" Expedition report is given a diagrammatic representation of what a cast of the interior of the coenoecium of *C. hodgsoni* would look like (17, plate 4, fig. 22); this sketch, as may be judged from the preponderance of terminal ostia, clearly applies to Form B.

It may seem inconsistent to state, as is stated above, that the average diameter of the inhabited cavity of the coenoecium in Form B is 4·5 mm., and that the ostia are funnel-shaped and measure only 3·5 by 2 mm., but in the first place it is the general disposition of the spines around the ostium that is largely responsible for creating the impression of a funnel, and it is only where the oval ring is actually complete, at the bases of these spines, that the ostium can be said to occur; it is only here that any measurement can be taken. In the second place, it will be readily understood how, by the swelling of the cavity just below a branching of the main axis or a lateral axis of the colony (17, plate 4, fig. 22), the cross-section of the cavity is, on the whole, larger than the size of a single ostium.

The common mode of multiplication of the ostia of Form B is by the bifurcation of the ostium at the end of the tube (text-fig. 11, p. 56, and explanation, pp. 56–57). There are also terminal ostia in Form A, but as the axial tube grows longer, the tendency is for a cross-bar to be secreted between two spines on one side of the ostium, and the new orifice, after reduction to about 3 by 2 mm., may remain as a lateral, sessile ostium when the tubular axis of the branch grows longer; or, by the addition of material to its edges, the oval ring may grow into a short lateral branch with a terminal ostium; or it may close up altogether (p. 57).

There are occasionally found, running across the internal cavity of the coenoecium of Form A, solid bars of about the diameter of spines, as though the growing end of a dwelling-tube had encountered an oblique spine or a connecting bar passing right across its terminal ostium, and instead of the obstruction having the effect of dividing the ostium into two ostia, the tube had continued to grow beyond it, leaving it as a trabecula or prop passing across the dwelling-cavity. Bars traversing the coenoecial cavity in this manner are not the exact equivalents of the irregularities found in *C. dodecalophus*, for in that species the smooth continuity of the inner surface of the wall is broken by irregular partitions, pockets and excavations (17, text-fig. 4, p. 8).

The spines of Form B, particularly the terminal spines, are longer and thicker than those of Form A, the average diameter being 1·0 mm. as against an average diameter of 0·75 mm. in the latter material. But one can without difficulty pick out slender spines of Form B that are thinner than specially selected thick spines of Form A. In basal parts of the colonies the differences in the spines are less marked than in the distal parts. In most cases the spines of Form B are more pale and transparent than those of Form A, but in rapidly growing apices of branches of Form A the coenoecial substance of both dwelling-tube and spines is exceptionally delicate, pale and transparent (*e.g.* in fig. 4 of plate 5, and in the uppermost part of fig. 5); in such parts the spines are very thin, sometimes not more than 0·4 mm. across.

The lines seen in the spines, marking the planes between the successive increments, are in Form B to a large extent longitudinally disposed, whereas in Form A they more readily suggest the successive application of short caps of coenoecial substance;

in other words, the cap-like increments, which really occur in both Forms, extend farther down the spine in Form B than in Form A.

One of the distinguishing features of Form A is the readiness with which the spines fork; in Form B they fork also, but less commonly than do those of Form A. The mode of forking of a spine in *Cephalodiscus* is not dichotomous, but by the application of a new spine to the side of an older one (17, plate 4, fig. 21), and the new spine may be longer than the part of the older spine that lies distally to the forking. The greatest amount of branching that I have noticed is a case in which one spine-base carried a total of seven spine-tips.

The general impression, gained by a casual glance, that there are more spines related to each ostium in Form A than in Form B, is due to the fact that the spines are more forked in the former. The basal parts of the spines are of about the same number in both—namely, if the ostia occur in a group of two, three, or four, usually two to each (text-fig. 10, *f*) ; if they occur singly, about three spine-bases to each. Counting the spine-tips in Form A, there would be about four or five to each solitary ostium.

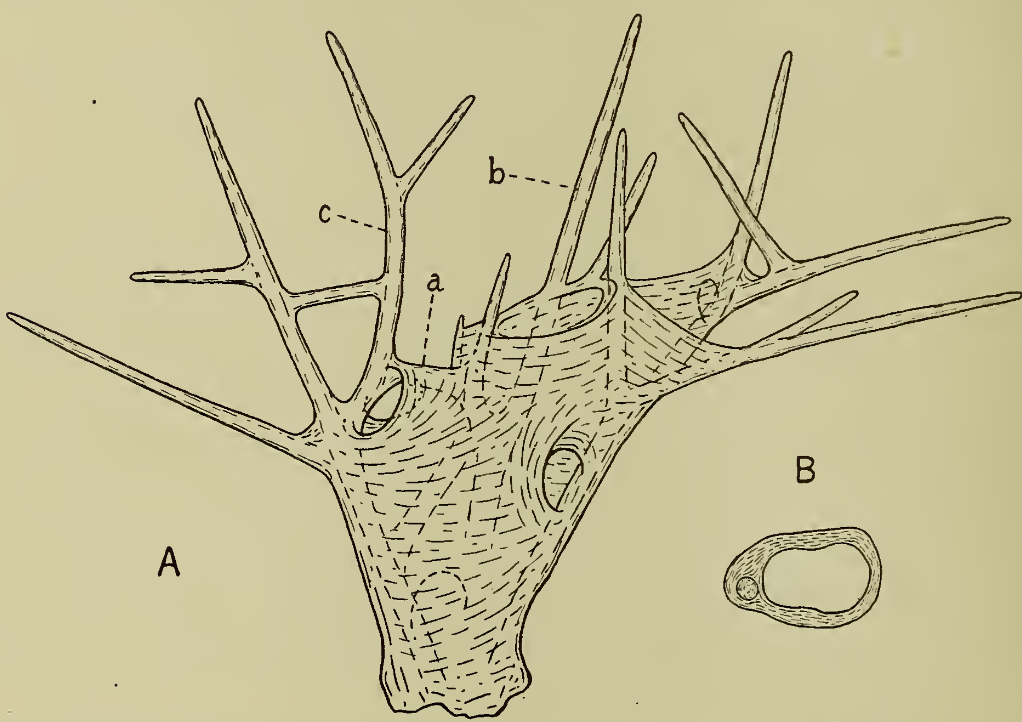
In Form A there is a tendency for cross-bars to connect up the spines, sometimes resulting in a complicated meshwork of bars and spines. In Form B the occurrence of such cross-connections between the spines is so uncommon that one has to search diligently to find them.

Many of the spines that are seen projecting freely from the surface of the coenoecium are embedded for a considerable proportion of their total length in the coenoecial wall*; this is particularly the case in Form A, but the remark applies also in a lesser degree to Form B. The embedded parts, one may assume, were at one time free spines, but they have since been covered in by the zooids, who have utilised the support afforded by them as a skeletal structure against which to attach the dwelling-tube at that time in process of elongation. Reference to text-fig. 9, B, will show that the innermost layer of the dwelling-tube is complete, and applied to the side of the spine, but the more external layers envelop the spine as well as the inner layers of the tube. One might say, indeed, that the whole coenoecium of a colony consists of a skeleton in the form of a continuously forking spine, with an irregular dwelling-tube running along it, sometimes on the near side, sometimes on the far side, while, coming off at various points from the main spine, and also independently of it, are other spines, not necessarily thinner, which stand out as the superficial spines, and fork and have cross-bars, but are not, or are not yet, essential components of the wall of the dwelling-tubes.

Perhaps the best method of explaining the differences that can be detected between Forms A and B of *C. hodgsoni* will be to describe in detail selected typical examples, such, for instance, as those represented in text-figs. 9 and 10.

* If a piece of colony without zooids be transferred through the usual grades of alcohol to benzene, and paraffin, and then taken back through benzene and alcohol rather rapidly, so as not to dissolve away all the paraffin, the main or axial supporting spines show up very distinctly.

In text-fig. 9 is shown a typical end-portion of a colony of Form A. The piece includes a total of seven ostia and fifteen spine-tips. The characteristic forking of the spines is seen, also a cross-bar to the left of spine *c*. At the base of the spine marked *b* is a large terminal ostium opening upward, and to the left of this are two lateral ostia, one on the near side and one on the far side of the base of spine *c*. These ostia, one may conclude from a study of the successive layers of growth of coenoecial substance, were preceded by a large terminal ostium, but the development of the cross-bar (*a*) had the effect of dividing it into two; the right-hand parts of the openings became closed up, and there now remain two lateral ostia. In the lower part of the figure is a lateral ostium on the farther side. A typical lateral ostium occurs on the near side on the

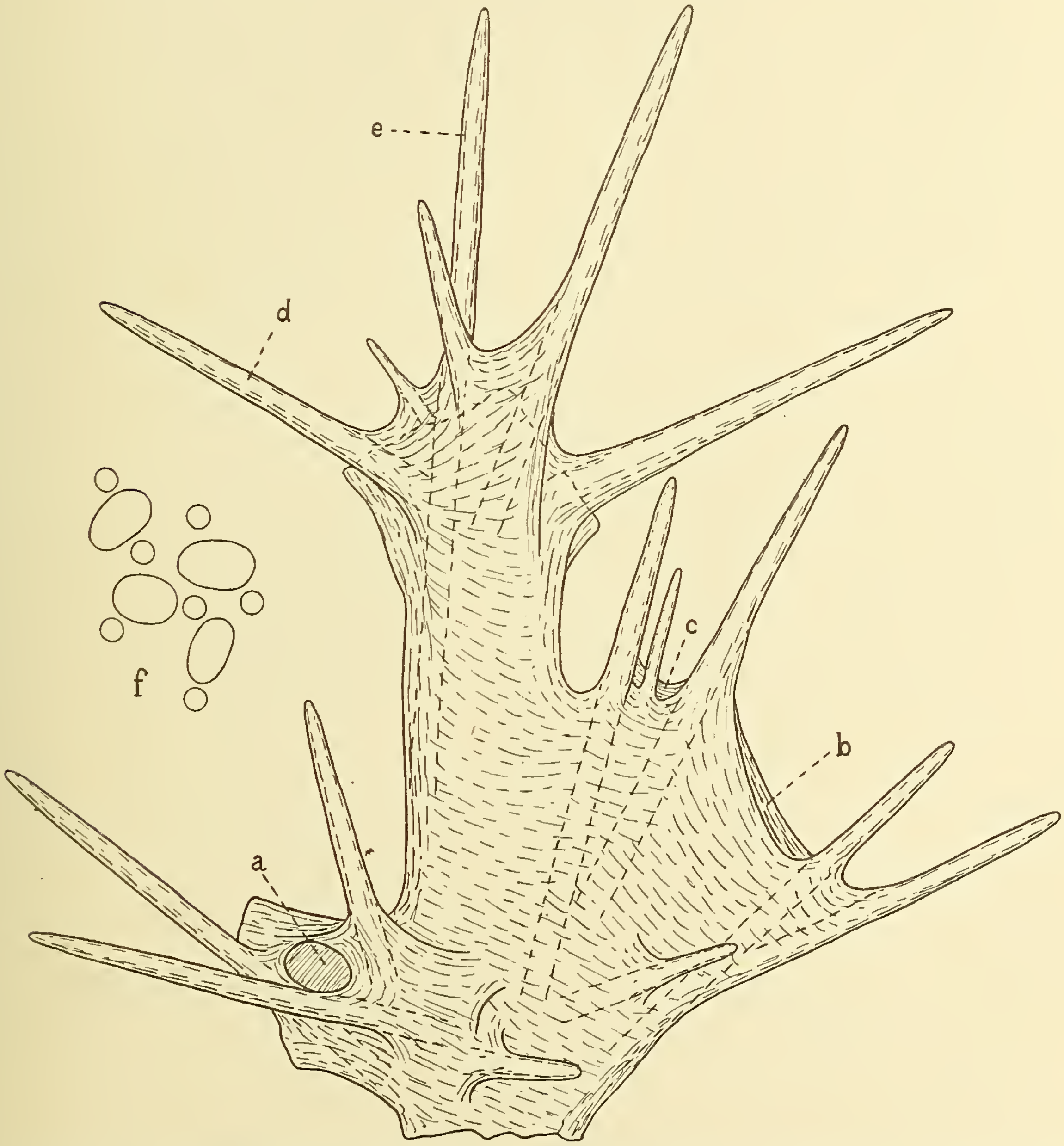


Text-fig. 9.—A—a typical end-portion of a colony of *C. hodgsoni*, Form A; Station 314. (× 3⅓.) For explanation of the lettering, see text, p. 54. B—transverse section of an internode of the axis of a colony of Form A, through a part where the cavity is at a minimum and no branches occur. Sometimes two spines are embedded in the wall, on opposite sides of the dwelling-tube.

right, and a smaller one, in the distance, high up on the right. To the left of this last ostium there is, on the far side, a terminal ostium not shown in the figure.

In text-fig. 10 is shown a typical end-portion of a colony of Form B. The piece includes a total of nine ostia and twenty spine-tips, but not all of these are visible from the side drawn. The spines are seen to be a little longer and thicker than those shown in text-fig. 9, and such forking as occurs is, in the particular piece selected for illustration, on the embedded parts of the spines, and not on the free portions of the spines as in text-fig. 9. In the left lower corner is an ostium (*a*), surrounded by three

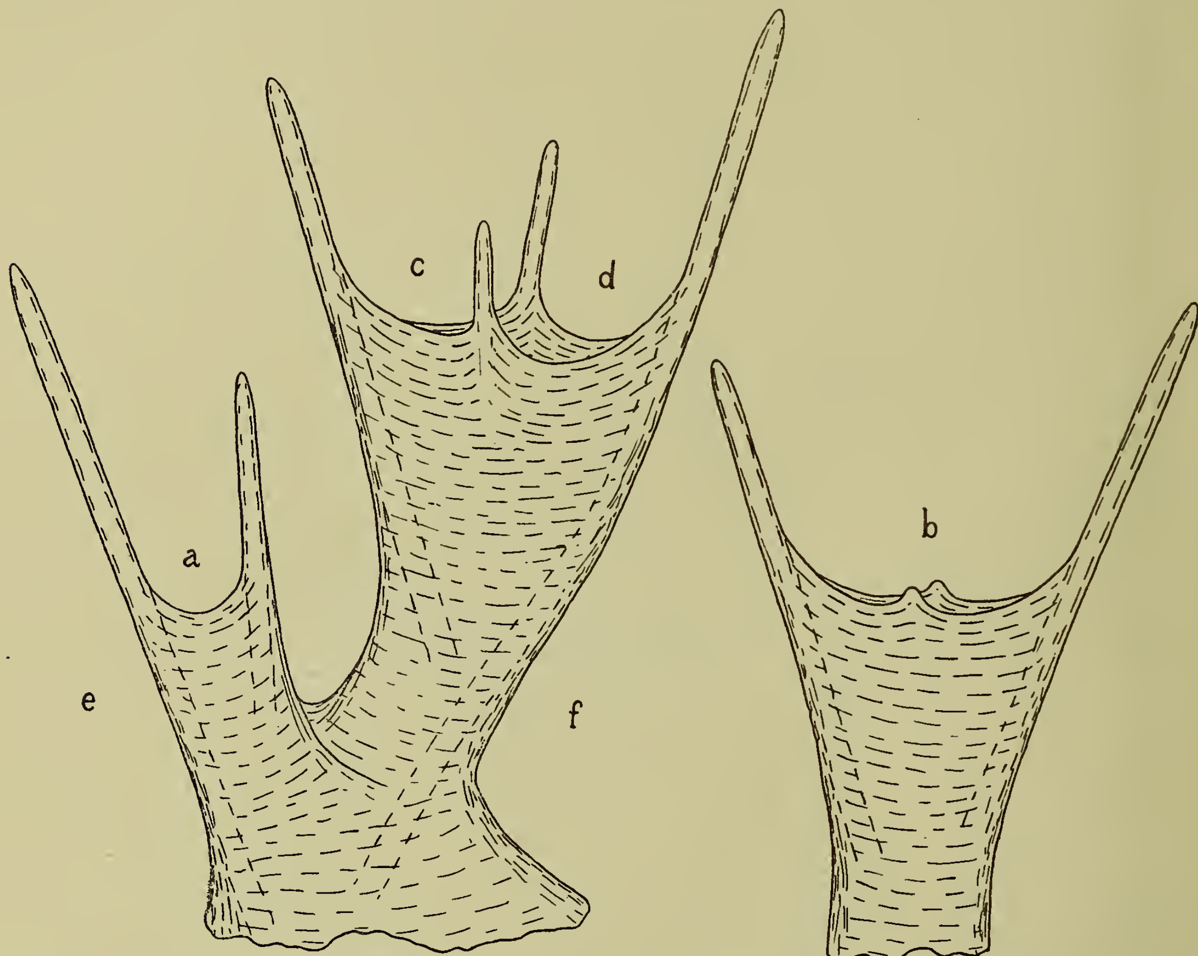
spines. This is a terminal ostium, set on the end of a short lateral branch; there is a similar ostium on the far side, not visible in the view taken. Near the middle of the lower part of the figure are two spines standing out obliquely towards the observer; these are not related to any ostium, though they probably were when first secreted.



Text-fig. 10.—A typical end-portion of a colony of *C. hodgsoni*, Form B; Station 348. (× $3\frac{1}{3}$.) For explanation of the lettering, see text, p. 54.

Constituting the whole right-hand portion of the lower half of the figure is a broad, short side branch with two terminal ostia (*b* and *c*), one of which (*c*) shows the beginning of a division into two, a small spine marking the position of such division. A similar

ostium in a state of division occurs between the spines *d* and *e*; one small spine at the division is seen, and another slopes away from the observer in the distance. There are on the far side of the upper part of the specimen—not visible from the front—two ostia and two spines; there is also a spine in the lower part of the specimen not seen in the view taken. So that, counting each dividing ostium as two ostia, and counting all the spines, small and large alike, there are in the figured specimen a total of nine ostia and twenty spines.



TEXT-FIG. 11.—Ends of branches of *C. hodgsoni*, Form B, partially diagrammatic, showing the mode of origin of new terminal ostia by the bifurcation of pre-existing ostia; Station 339. (× $3\frac{1}{3}$.) For explanation of the lettering, see text, p. 56.

Figure *f* of text-fig. 10 is a diagram of an end-view of a group of four ostia of Form B, with the associated seven spines cut short. There are, that is to say, roughly twice as many spine-bases as there are ostia, a proportion which conforms with that found in the piece of colony described in the preceding paragraph.

A common mode of origin of new terminal ostia in Form B, by the bifurcation of pre-existing ostia, is explained in text-fig. 11. A simple ostium such as is seen at *a* grows wider as the dwelling-tube and the spines lengthen, and acquires the form of an oval

funnel, the spines being situated usually, but not invariably, at the ends of the longer diameter. A pair of new spines begin to develop on the edges of the oval, as at *b*, and after the tube and the four spines have lengthened, as at *c d*, a connection is established between the two new spines, so as to divide the oval orifice into two nearly circular ostia. As the two tubes, each now with two spines, become longer, and the ostia grow more funnel-shaped, a time comes when the two parts are short separate branches such as are seen at *e* and *f* in the lower part of the figure.

A common mode of origin of new ostia in Form A, on the other hand, is by two diverging spines becoming connected, fairly low down, by a cross-bar such as is seen to the left of spine *c* in text-fig. 9. Applications of coenoecial substance reduce this triangular aperture to an oval one, and the dwelling-tube grows up along the side of the spines as far as the cross-bar, and ultimately beyond it, leaving the orifice as a lateral ostium. Commonly the triangular space is closed up completely, and the sheet of substance becomes part of the wall of the dwelling-tube.

SPECIES OF THE SUB-GENUS *DEMIOTHECIA*.

The sub-genus *Demiothecia*, Ridewood (17, p. 8) was founded to include those species of *Cephalodiscus* in which the cavity of the coenoecium* is continuous throughout the colony, and to exclude those species in which each perfect zooid dwells in a tubular cavity of its own. Until the appearance of Andersson's report (2) the sub-genus included the species *C. dodecalophus*, M'Intosh, *C. gracilis*, Harmer, *C. sibogae*, Harmer, and *C. hodgsoni*, Ridewood ; to these Andersson added two species, *C. aequatus* (2, p. 9) and *C. inaequatus* (2, p. 10), which are less clearly differentiated than the four preceding species.

The species of *Demiothecia* are extremely difficult to distinguish, either by the characters of the coenoecium or by those of the zooids. *C. gracilis* and *C. sibogae* may be separated off from the others by reason of the diminutive size of the coenoecium, and also of the zooids, although the latter are not readily distinguishable the one from the other, because of the fact that male zooids of *C. gracilis* and female zooids of *C. sibogae* are not known. Indeed, Harmer (10, p. 4) states that the possibility is not excluded that *C. sibogae* is the male form of *C. gracilis*. As regards the remaining species the difficulty of discriminating between them is very considerable.

The material dredged on the Swedish South-Polar Expedition from Stations 59

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* *Coenoecium.* Despite the arguments brought forward (17, p. 20, footnote) against the use of the term coenoecium to designate the secreted dwelling of the Pterobranchia, the alternative term suggested —tubarium—has not met with general acceptance. While the word tubarium is appropriate in the case of *Rhabdopleura*, *Orthoecus* and *Idiothecia*, its suitability when dealing with species of *Demiothecia* is less obvious, and this may account in some measure for the term not having come into general use. While still maintaining the inappropriateness of applying to a free secretion, which when once solidified has no longer any organic connection with the body, a term employed in the first instance to designate the locally thickened cuticle of the hinder part of the body in Polyzoa, I feel that no useful purpose is likely to be served by continuing the use of a term that fails to meet with general approval.

and 73, and referred by Andersson to the species *C. dodecalophus*, is stated by that author to be more massive and provided with longer spines than the type-material of *C. dodecalophus* figured by M'Intosh (14, plate 1, and plate 7, fig. 1), and in these respects his material approaches *C. inaequatus* (2, p. 9). The single piece of *C. dodecalophus* obtained from Station 58 is more slender and with thinner spines, but it is very different in appearance from the typical material obtained by the "Challenger." Andersson himself was apparently somewhat doubtful about the identification (2, p. 9).

As regards *C. inaequatus*, arguments have been adduced (11, pp. 559–563) to show that this is not distinguishable from *C. hodgsoni*, and should be regarded as a synonym of it. Andersson, on the other hand, while of opinion that *C. aequatus* approaches *C. hodgsoni* (2, p. 8), says nothing of the close relationship that exists between *C. inaequatus* and *C. hodgsoni*.

The difficulty of instituting any comparison between the coenoecia of the species under consideration from an examination of the published figures is increased by the fact that the illustrations look so unlike the real objects. The figures of *C. hodgsoni* (17, plate 2, fig. 1, A and B) are reproduced from photographs, but they give a very imperfect suggestion of the appearance of the coenoecium, the effect of "depth" and "distance" in the photograph having been lost in reproduction by the "half-tone" process. The figure of *C. inaequatus* given by Andersson (2, plate 2, fig. 1) is reproduced by a different process, apparently a lithographic process, and the background is white instead of black. This figure and those of the "Discovery" material of *C. hodgsoni* represent the coenoecium as of natural size, but owing to the different methods of reproduction a fair comparison cannot be made. Fortunately some small pieces of the "Antarctic" material of *C. inaequatus* from Stations 5 and 94 of the Swedish Expedition were sent to the British Museum from Stockholm, and it was thus possible to effect a direct comparison with the "Discovery" material of *C. hodgsoni*.

C. aequatus Andersson admits to be very near *C. hodgsoni* (2, p. 8), but he distinguishes it largely by the fact that *C. hodgsoni* has hermaphrodite individuals as well as male and female, a not very substantial difference, considering that the whole of the material of *C. aequatus* was obtained on the same date and from the same locality. Further, it may be pointed out, hermaphrodite individuals in *C. hodgsoni* are not very common; it may very possibly be that, in the material of *C. aequatus* collected, hermaphrodites were present, but escaped detection.

Again, *C. aequatus* is stated by Andersson (2, p. 9) to approach so nearly to *C. dodecalophus* that he long hesitated before deciding that it should constitute a distinct species, and the decision turned mainly on the fact that up to the present no male zooids of *C. dodecalophus* have been found, whereas in the material of *C. aequatus* male and female zooids occur in approximately equal numbers in the same coenoecium (2, p. 9). As an argument logically applied, this would mean that anyone so fortunate as to dredge a colony of *C. dodecalophus* containing male zooids would have to admit that, since it contained male zooids, it could not be *C. dodecalophus*.

The possibility of *C. aequatus* being the same as *C. dodecalophus* Andersson considers to be reduced by the fact that the station from which the former was obtained lies in the antarctic region, whereas all the known material of *C. dodecalophus* has been dredged from sub-antarctic localities, with distinctly higher bottom-temperature than that of Station 94 of the Swedish South-Polar Expedition.

The coenoecium of *C. aequatus* is stated by Andersson (2, p. 10) to agree in the main with that of *C. inaequatus*, but is less strongly developed—the coenoecium of *C. inaequatus* is "kräftiger entwickelt." *C. aequatus* is not figured by Andersson, and a piece of a colony from Station 94 of the Swedish Expedition, received by the British Museum from Stockholm, is taken from a part too near the base of the colony to give one a clear idea as to what the branching of the colony is like. So far as one can judge from this piece, however, *C. aequatus* approaches Form B of *C. hodgsoni* rather than Form A. It has thicker and straighter spines, with less netting by cross-bars than is common in Form A; but while, on the whole, Form B is of larger build than Form A, *C. aequatus* is smaller, with the inhabited cavities of the coenoecium narrower. The zooids of *C. aequatus* measure about 2·0 mm. from the free ends of the arms to the end of the body, which is roughly the size of the zooids of Form B, whereas those of Form A are, on an average of a large number of cases, slightly larger.

If it should subsequently transpire that there is no very strong reason for separating *C. aequatus* from *C. inaequatus*, and consequently from *C. hodgsoni*, it might be regarded as a diminutive example of Form B. The conclusion would be supported by the general purplish red colour of the zooids in both, and by the number of arms being in a majority of the zooids twelve, in both sexes, in *C. aequatus* and Form B of *C. hodgsoni*.

Re-examination of the material of *C. hodgsoni* obtained on the "Discovery" Expedition goes to show that most of it, including the type-specimen (Specimen A; 17, plate 2, fig. 1, A) is of Form B; the inhabited cavity of the coenoecium has a tendency to dilate into funnels and gaping terminal ostia, and the spines are fairly coarse, with little looping up by cross-bars to form meshes and lateral ostia. But the larger piece figured (Specimen B; 17, plate 2, fig. 1, B) approaches Form A*, as also do Specimens C and F; they show a certain amount of forking of the spines and netting by cross-bars, a profusion of small lateral ostia, and a smaller coenoecial cavity than is typical of Form B; but none of the three is typically Form A, their terminal spines are rather long, and more resemble those of Form B in thickness and straightness.

At the British Museum (Natural History) there are two pieces of *C. inaequatus* obtained on the Swedish South-Polar Expedition, one from Station 94 and the other from Station 5. That from Station 94 is clearly Form A, the other is doubtfully Form B. It is strange that in the latter material males are rare, whereas in that from Station 94 they are common (equal in number to the female zooids—2, p. 85); this is

* But one cannot judge from the published figure.

just the reverse of what is found to occur in the "Terra Nova" material, for in Form A almost all the zooids are female, whereas pieces of colony of Form B with male individuals are as common as pieces with female zooids. It may be that at a certain season of the year a colony changes sex, by the newly produced buds being of a different sex from their parent, although up till that time the buds had been of the same sex. A male zooid with a female bud is recorded in the "Discovery" Expedition report (17, p. 58).

EMPTY COENOECIA OF *CEPHALODISCUS*.

A large proportion of the material of *C. hodgsoni* collected is "dead," consisting of coenoecium only, with no zooids. The "dead" pieces of colony are somewhat more brittle than those in which zooids occur, and the coenoecial substance is not bright and clear, but usually rather turbid and feebly opalescent. The coenoecial substance of *Cephalodiscus*, although shown in Andersson's report (2, p. 20) to be albuminoid in character, seems to be remarkably resistant, and probably remains more or less unaltered at the bottom of the sea for years after it has ceased to be inhabited by zooids.

In order to test the imperishable character of the coenoecial substance, a piece of colony of *C. hodgsoni*, Form A, free from zooids, was soaked in distilled water for two years exposed to the air, but lightly covered to exclude the dust. At the end of this period no difference was to be seen between the piece thus treated and a control portion of the same colony kept in alcohol. For the purpose of this experiment alcohol-fixed material was chosen in preference to that preserved in formalin solution, for it is well known that formalin has upon certain organic substances, such as gelatine, the effect of converting them into other substances that are resistant to the organisms of putrefaction.* It is unfortunate that in Andersson's report (2, pp. 19–20) it is not stated what was the method of preservation of the material upon which Prof. Mörner conducted his investigations. In the case of future collecting expeditions it might be well for the biologist in charge to prepare some coenoecial substance with a special view to chemical investigation. For this purpose the various species of *Demiothecia* are better adapted

* To verify this statement, a sheet of gelatine was soaked in water for twenty minutes to soften it, and then divided into two parts. One part was left in water. On the third day putrefaction was well advanced; the gelatine had swollen considerably more than at first, and the water emitted an extremely foul odour. On the ninth day there was no longer any offensive smell; the gelatine had practically disappeared, and all that remained in the water was a light flocculent sediment; at the end of three weeks the sediment had gone, and all that could be seen was a colourless slime, probably a growth of *Leptothrix* or *Cladothrix*. The other part of the sheet of softened gelatine was transferred to a 4 per cent. solution of formalin for three hours, and then given several changes of water for two days to remove the last trace of free formalin. At the end of three weeks no change had occurred; the appearance of the gelatine was the same as before, and there was no foul smell or other evidence of putrefaction. At the end of the fourth week, however, there were signs of disintegration, and at the end of the fifth week the gelatine had disappeared. The water was a little turbid, and the smell, though slightly unpleasant, was not offensive.

than those of *Idiothecia* and *Orthoecus*, because of the ease with which the coenoecial substance can be freed from the remains of the zooids. The preparation of the material might be conducted as follows:—the branches, after soaking in several changes of distilled water to remove the salt and the sand-grains, are cut up into small pieces to ensure that all portions of zooids are removed; after drying quickly at a temperature of about 50° C., the pieces are put into a dry bottle or tin, and stored until, on the return of the expedition, the substance can be handed over to a chemist for analysis.

It does not necessarily follow that because no zooids are found in it a coenoecium was unoccupied or "dead" at the time of dredging. In the largest colony that was obtained—that mentioned first in the list of material on page 49—there are very few zooids; but even if there were none at all, one would not gain the impression that the colony was "dead," for the extremities of the branches are very pale and delicate, and have the appearance of being but recently secreted. The scarcity of zooids in this specimen, and the absence of zooids in some similar but smaller pieces of colony in the collection, are rather to be accounted for by the ease with which the zooids of the various species of *Demiothecia* may become dislodged if the specimen remains for any length of time in the trawl.

ZOOIDS OF *C. HODGSONI.*

A fairly exhaustive examination of zooids from pieces of colony selected from the various bottles in which the collection arrived fails to justify any very definite generalisation regarding the relations subsisting between (*a*) the colour of the zooids, (*b*) the number of arms of the zooids of Forms A and B, and (*c*) the two sexes of these Forms.

In his diagnosis of *C. inaequatus* Andersson (2, p. 10) states that female individuals have five pairs of arms and males have six pairs. In the original account of *C. hodgsoni* (17, p. 55) it is observed that "the normal number of plumes is twelve, but . . . a full-sized polypide, . . . with well-developed ovaries, may have only ten fully-grown plumes." The suggestion that there might be some correlation between the number of arms and the sex of the zooid had not occurred to the author, whose paper appeared before that of Andersson. In the report on the Pterobranchia of the Scottish Antarctic Expedition (11, pp. 560–562) the question is discussed in connection with the synonymy of the two species just mentioned.

In order to ascertain if in the material collected by the "Terra Nova" any relation could be found to exist between the number of the arms of a zooid and its sex in Forms A and B respectively, not less than 150 zooids were dissected, in the manner described on page 21. Of these zooids, 96 were of Form A, and 54 of Form B.

One result of this examination is the discovery that very rarely are male and female zooids found in the same colony; the only instance of associated sexes is in a piece of material of Form A from Station 339, with zooids of both sexes in mature

condition. The only hermaphrodite zooids that were found, and the only male zooids of Form A, were from this colony.

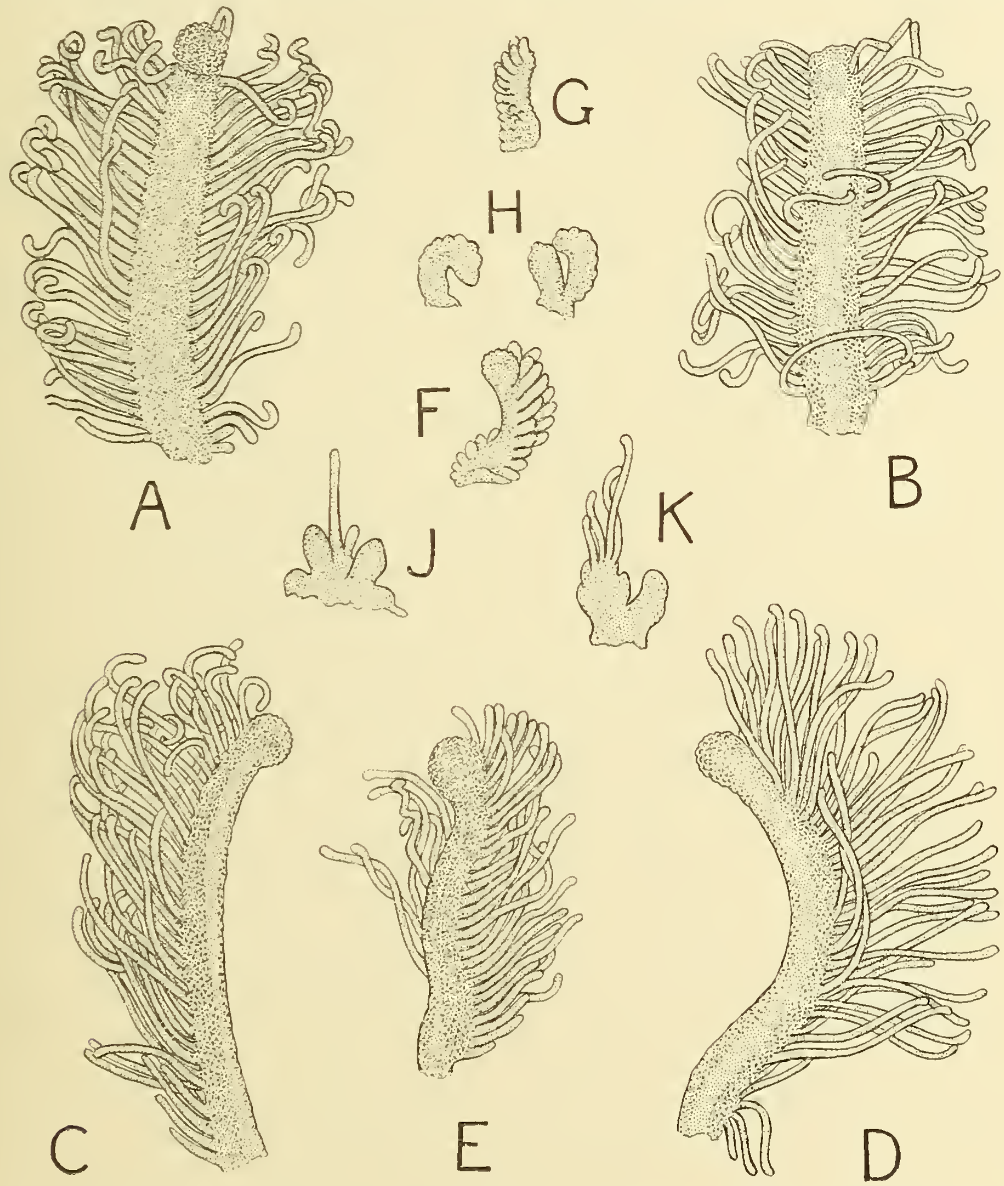
Another observation is that all the female colonies have zooids the majority of which are in an extremely immature condition, the gonads in some cases being so minute that the only means of deciding the sex was to stain them and examine them under the high power of the microscope.

Of the pieces of Form B examined, one had zooids with minute ovaries, and arms varying from eleven to twelve; another had zooids with testes, and arms from eleven to twelve; another had zooids with minute ovaries, and twelve arms; another had zooids with small ovaries, and arms from nine to eleven; another had zooids with ripe testes, and arms from ten to twelve; another had zooids with extremely minute gonads, recognisable in most but not all cases as young ovaries, and arms from ten to twelve. In the piece of colony last mentioned (from Station 339) minute or arrested arms are unusually common; they are reckoned in the counting as if they were full arms.

Of the pieces of colony of Form A examined, that referred to in the fourth paragraph of this chapter had zooids with ripe ovaries and testes, and ten arms: another piece had zooids with gonads too minute to identify with certainty, but the indications were in favour of their being young ovaries, and the arms, though definitely ten in twenty-three zooids (in two of them there were eight large and two minute arms), were doubtfully nine in one case and certainly eleven in another. Another piece of colony was almost identical with the last; fifteen zooids were examined, and in all of them the gonads were extremely minute, in two cases definitely recognisable as ovaries; the arms were in all cases ten, counting dwarf arms as fully developed arms. Another piece was similar to the last in the zooids having ten arms each, but of the nine zooids examined two had fully developed ovaries, one had minute ovaries, and the other six had gonads too small to enable one to decide the sex. Another piece had zooids possessing ten arms each, and of the eight zooids examined one had large ovaries, five had small ovaries, and two had minute gonads of doubtful sex. Another piece had zooids with ten arms and extremely minute, doubtful gonads. Another piece had zooids with ten arms in thirteen cases, and doubtfully nine in two others, and gonads that were minute ovaries in all the zooids except four, in which they were too small to decide the sex. Another piece had zooids with ten arms in thirteen cases and doubtfully ten in two others, and minute gonads, recognisable as young ovaries in two cases only.

Reviewing the results set out above, it is seen how difficult it is to establish any certain correlation between the three variables—(1) number of arms, (2) sex, (3) Forms A and B. Form A seems to be characterised by the possession of ten arms, even in the few males that were encountered; but one zooid of the total of ninety-six investigated had undoubtedly eleven arms. In the case of Form B, pieces of colony with male zooids are as abundant as those with female zooids, and although in a

proportion of cases the arms are eleven, ten, or even nine in number, yet there are many instances in which both male and female zooids have twelve arms each. These conclusions, however, are rather discounted by the fact that in reckoning the arms, arrested arms were searched for and were counted as complete arms, for arrested arms are more common in Form B than in Form A. If arrested arms were



Text-fig. 12.—*Cephalodiscus hodgsoni*, arms of adult zooids. A, a moderately contracted arm, in flat view. B, an arm without an end-swelling. C, a moderately extended arm, in side view. D, an extended arm, with small end-swelling. E, a contracted arm, with large end-swelling. F, a small but complete arm found among others of full size. G, a smaller arm, less complete. H, three arrested arms from one zooid. J, two arm-bases, presumably the remains of injured arms. K, a similar arm-base, with a few tentacles of full length. × 48. All are from Station 339, except D and E, which are from Station 348. Figures C–H are of Form B, figures A, B, J and K are of Form A.

disregarded, and only functional arms counted, the numerical disproportion would be less striking.

A selection of arrested arms and damaged but healed arms is shown in text-fig. 12, F–K, drawn to the same scale of magnification as a number of normal arms (A, C, D), and two other arms, one (E) with an exceptionally large end-swelling, and the other (B) without an end-swelling.

On the whole, considering the difficulty experienced in drawing any decisive distinction between Forms A and B based upon their coenoecial characters (pp. 51–57), the generalisation that zooids of Form A have mostly ten arms in both sexes, and those of Form B mostly twelve arms in both sexes, does not seem to warrant the recognition of Forms A and B as distinct species of the sub-genus *Demiothecia*.

Further, the investigation of the present material does not lend support to the thesis made by Andersson (2, p. 10) in respect of *C. inaequatus* that there is any regularity in the possession of ten arms by female and twelve arms by male zooids. It may be noted here that in the related species, *C. aequatus*, Andersson (2, p. 9) reports the number of arms as twelve in both sexes; but it has already been explained (p. 59) that Form B cannot be regarded as the same as *C. aequatus*, since although the zooids agree fairly well in size and colour, the coenoecium of Form B is much larger than that of *C. aequatus*, the coenoecium of Form A being intermediate between the two. Even if Form B were considered as a giant form of *C. aequatus*, and pieces of colony of composite character (Form A and Form B combined) were regarded as the product of two species of zooids living harmoniously together, but not interbreeding, yet the pieces of colony of intermediate character, pieces that cannot be definitely relegated to the one Form or the other, still offer an insuperable difficulty.

The colour of the zooids does not afford any real assistance in the matter, for while one can say in a general way that, in both material preserved in alcohol and that preserved in formalin, the zooids of Form B are of a purplish brown or a dull crimson, while those of Form A are usually of a dull earthy brown (raw umber), fading in time to greyish brown, ochreous or cream-colour, yet there are significant exceptions in some pieces of Form A with distinctly red zooids—*e.g.* that shown in plate 5, fig. 3, and the piece of colony from Station 339 with both male and female zooids; in this last the red colour is not confined to the zooids of one sex. That differences in colour are not due to the particular fluid employed for preservation is clear from the fact that in a bottle of material in which both Form A and Form B occur the zooids of the latter are distinctly more crimson than those of the former.

Serial sections were cut of selected zooids of Forms A and B, but the study of them does not elicit any constant differences between the two Forms, nor any new features of general morphological interest.

No differences are to be distinguished between the buds of Forms A and B. The buds of *C. hodgsoni* have previously been dealt with in a fair amount of detail

(**17**, pp. 60–62, and **18**, pp. 224–230), and there are no new observations to record from the present material.

In material of Form A from Station 355 several zooids are found with a rounded or bluntly pointed anterior end destitute of shield, arms, oral lamella and mouth; the stalk, on the other hand, is complete, with apparently healthy buds. Similar defective zooids have been previously noted in two species of *Cephalodiscus* besides *C. hodgsoni* (*C. gracilis*, **10**, p. 93; *C. dodecalophus*, **14**, plate 3, fig. 4; *C. hodgsoni*, **17**, p. 53 and plate 6, fig. 52).

Instances of the double budding of the same stalk, similar to those observed in material of *C. nigrescens* of the "Discovery" Expedition (**17**, plate 7, figs. 69 and 73), were found in material of *C. hodgsoni* from Station 348.

Free ova occur in numerous instances, and are attached to the inner surface of the wall of the colony by a short stalk of coenoecial substance, which also spreads over the egg-shell. They measure usually about 0·7 by 0·5 mm., but some were found in which the length is as great as 1·0 mm. There seems to be no difference in size between the free ova of Forms A and B. In the original description of *C. hodgsoni* the size is stated to be 0·47 by 0·42 mm. (**17**, p. 58), but free ova were found in one colony only (Specimen D) of the "Discovery" material, and the size is probably understated; the ova may have been exceptionally shrunken.

FOREIGN OVA FOUND ON THE COENOECIUM.

In material of *C. hodgsoni* from Stations 314, 316, 338 and 355 are to be found, among the spines on the exterior of the coenoecium, solitary, oval, transparent eggs, each with a small red body within, and a quantity of thick fluid, that is clear and glairy in formalin, but coagulated in alcoholic material. The eggs measure 4·3 by 2·8 mm., and thus cannot be mistaken for eggs of *C. hodgsoni*. The shell is smooth, tough, flexible and transparent, and each egg is smeared over with layers of coenoecial substance.

These are clearly foreign eggs that have been laid by the parent upon the branches of the *Cephalodiscus*, and have subsequently been covered over with coenoecial substance by the zooids, and they are only worthy of mention here from the fact that they are conspicuous objects, and cannot fail to attract the attention of anyone who at some future time may have occasion to examine this particular material. Although the eggs are fairly numerous, only two were found sufficiently advanced in their development to enable one to say definitely that they are eggs of a gastropod mollusc with a spiral shell. Mr. G. C. Robson, who has been good enough to examine the shells, identifies the mollusc as a kind of *Voluta*.

SYNOPSIS OF THE SPECIES OF *CEPHALODISCUS* AT PRESENT KNOWN, AND LIST OF ALL RECORDED SPECIMENS.

Material of the following species has not been examined by the present writer:—*C. gracilis*, *C. sibogae*, *C. levinseni*, *C. anderssoni*, *C. indicus*; the particulars given are drawn from the works cited under the respective headings.

Statements given here that do not occur in the diagnoses of the original authors have been introduced either as the result of a study of their published figures and text, or from an independent examination of material by the present writer.

C. indicus was placed by its author (Schepotieff, 22, p. 435) in the sub-genus *Idiothecia*, but with sub-generic diagnoses as here adopted the species falls within the sub-genus *Orthoecus*—see p. 19.

The geographical distribution of the various species of *Cephalodiscus* is illustrated by the two maps in plate 6.

SUB-GENUS *DEMIOTHECIA*, Ridewood.

Sub-genus *Demiothecia*, Ridewood.—Colony branching. Each ostium of the coenoecium leading into a cavity which is continuous through the colony, and is occupied in common by the zooids and their buds. Transverse sections of the branches showing the central cavity surrounded by a wall of coenoecial substance, usually of irregular thickness, and sometimes with inwardly projecting bars and ridges.

C. dodecalophus, M'Intosh.—Colony irregularly branched and straggling; some of the branches fusing up to form a network, the cross-bars being usually solid. Maximum size of known specimens—215 mm. high, 195 mm. wide. Coenoecium pale orange-brown or colourless. Distance from one branch or cross-connection to the next about 22 mm.; width of a branch, not including spines, 3·5 to 6 mm. Cavity of coenoecium continuous, but partially divided up by bars, ridges and incomplete partitions; occupied in common by the zooids and their buds. Ostia numerous, irregularly placed, oval, 1·5 by 0·7 mm., sessile—*i.e.* without peristomial tubes—sometimes even sunk below the general surface. Spines not obviously related to the ostia, simple, forked, or branched, length—3 to 8 mm., rarely as much as 15 mm., width about 0·5 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—2·0 mm.; length from bases of arms to end of body—1·3 mm.; width of body—0·7 to 0·8 mm. Colour (of preserved zooids) whitish or cream-coloured, but in 1882 the arms of the zooids of the "Challenger" material were pink or violet. Arms usually six pairs, sometimes five pairs; axis of each arm with an end-swelling, with refractive beads. Testes—(males not known). Free ova 0·33 mm. across, attached by a stalk. Buds one or two, rarely three, to each zooid.

Locality—Straits of Magellan; Lat. 52° 45′ 30″ S.; Long. 73° 46′ 0″ W.; dredged on the "Challenger" Expedition, 1873–1876, Station 311; 245 fms. (448 m.); January 11th, 1876; several pieces.

Described by W. C. M'Intosh and S. F. Harmer, 14. For preliminary notices see footnote on page 13.

Material referred to *C. dodecalophus* has since been obtained from three localities, on the Swedish South-Polar Expedition ("Antarctic"):—

Station 58.—Lat. 52° 29′ S.; Long. 60° 36′ W.; between Falkland Islands and Burdwood Bank; 108 fms. (197 m.); Sept. 11th, 1902; one piece was dredged, and a small portion of it was saved from the "Antarctic" before it sank.

Station 59.—Lat. 53° 45′ S.; Long. 61° 10′ W.; between Falkland Islands and Burdwood Bank; 75–82 fms. (137–150 m.); Sept. 12th, 1902; two pieces dredged, but only a small portion saved.

Station 73.—Lat. 54° 55′ S.; Long. 67° 41′ W.; east of southern end of Tierra del Fuego, Beagle Channel; 44–128 fms. (80–235 m.); Oct. 30th, 1902; some pieces dredged, but none saved; some embryos and larvae were saved.

This material is described by K. A. Andersson, 2. The piece of material figured (2, plate 2, fig. 3) does not exhibit the characteristic features of the coenoecium mentioned in the diagnosis given above; if correctly referred to *C. dodecalophus*, it may be a basal portion of a young colony, or a particularly bushy piece from the end of a branch.

The specimens mentioned above are referred to by Andersson in a preliminary note published in the Zool. Anzeiger of 1903 (1). He gives to the note the title "Eine Wiederentdeckung von *Cephalodiscus*," and makes no suggestion as to the possibility of the new material being of a different species from that which up till then was the only species known. Of the four localities mentioned two agree with Station 58 and Station 73 of the full report of 1907 (2); the other two are:—Off Cape Seymour; Lat. 64° 28′ S.; Long. 56° 43′ W.; 82 fms. (150 m.); January 16th, 1902; and on the Burdwood Bank; Lat. 53° 53′ S.; Long. 58° 47′ W.; 82 fms. (150 m.). These localities do not agree precisely with any of those mentioned on the first page of his full report, but they are presumably the same as Station 5 and Station 59, in which case the material obtained from the former is that to which he gave the name *C. inaequatus*, and the material from the latter, as also the material from Station 58 and Station 73, is that which he identified as *C. dodecalophus*.

C. hodgsoni, Ridewood.—Colony irregularly branched, without cross-bars connecting up the branches. Maximum size of known specimens—250 mm. high, 150 mm. wide ("Terra Nova" specimen). Width of a branch, not including spines, mostly 4 to 6 mm., but some terminal branches as narrow as 3 mm., and some basal stems as thick as 9 mm. Cavity of coenoecium irregular, continuous, and occupied in common by the zooids and their buds. inner surface smooth, cavity sometimes traversed by solid bars.

Older parts of the coenoecium of a deep amber colour, younger parts colourless. Ostia numerous, irregularly placed, oval, lateral or terminal; terminal ostia rather funnel-shaped, about ·3 by 2 mm., lateral ostia smaller, mostly sessile; each ostium with from two to five long, more or less radiating spines, simple, forked or branched; length of spines up to 20 or 25 mm., but the spines of rapidly growing terminal branches commonly shorter (8 to 12 mm.); spines frequently connected by cross-bars, forming an imperfect mesh-work; width of spines—0·6 to 1·0 mm., in terminal branches sometimes not more than 0·4 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—2·0 to 3·2 mm.; length from bases of arms to end of body—1·0 to 1·8 mm.; width of body—0·6 to 1·0 mm. Colour (of preserved zooids) crimson-brown or pale brown, fading to ochreous and cream-colour. On the assumption that *C. inaequatus* is synonymous with *C. hodgsoni*, colour of living zooids red or crimson, the body darker and more brown than the arms. Arms five or six pairs; axis of each arm with an end-swelling, with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony, but males or females usually preponderating. Testes short. Free ova measuring 0·5 by 0·4 mm., up to 0·8 by 0·6 mm., attached by a stalk. Buds two, sometimes three or four, to each zooid.

Localities—Ross Sea, east end of Barrier; Lat. 78° 16′ 14″ S.; Long. 197° 41′ 47″ E. (= 162° 18′ 13″ W.); 100 fms. (183 m.); Jan. 29th, 1902; five pieces. Off the Barrier; Lat. 78° 20′ 30″ S.; Long. 174° 13′ 12″ W.; 300 fms. (549 m.); Jan. 27th, 1902; one piece. In McMurdo Sound, South of Ross Island; Lat. 77° 50′ 30″ S.; Long. 166° 44′ 45″ E.; 130 fms. (238 m.); one piece May 18th, 1903, and one piece June 3rd, 1903; dredged on the National Antarctic Expedition ("Discovery").

Described by W. G. Ridewood, 17.

Material of *C. hodgsoni* was obtained in the Graham Region on the Swedish South-Polar Expedition of 1901–1903; it is described under the name *C. inaequatus*, but evidence has been brought forward (11, pp. 559–563) to show that it is not distinguishable from *C. hodgsoni*. For the localities of this material see *C. inaequatus* (*infra*).

Material of *C. hodgsoni* was obtained on the Australasian Antarctic Expedition of 1911–1914. From Station 1, in Commonwealth Bay, Adélie Land; Lat. 66° 50′ S.; Long. 142° 6′ E.; 354 fms. (647 m.); Dec. 22nd, 1913; several pieces. From Station 8, off Queen Mary Land; Lat. 66° 8′ S.; Long. 94° 17′ E.; 120 fms. (219 m.); Jan. 27th, 1914; several pieces. From Station 12, off Shackleton Glacier, Queen Mary Land; Lat. 64° 32′ S.; Long. 97° 20′ E.; 110 fms. (201 m.); Jan 31st, 1914; several pieces.

Described by W. G. Ridewood, 21.

Material of *C. hodgsoni* was obtained on the British Antarctic ("Terra Nova") Expedition of 1910–1913, from McMurdo Sound, Ross Sea, Stations 314, 316, 338, 339, 340, 348 and 355, at depths between 140 fms. (256 m.) and 300 fms. (549 m.), on dates between Jan. 23rd, 1911, and Jan. 20th, 1913; many pieces.

Described in the present report, pp. 48–65.

C. inaequatus, Andersson.—The species is here regarded as a synonym of *C. hodgsoni* (*q.v.*) The evidence for this view is given in 11, pp. 559–563.

Localities—Graham Region, S.E. of Seymour Island; Lat. 64° 20′ S.; Long. 56° 38′ W.; 82 fms. (150 m.); Jan. 16th, 1902; and North of Joinville Island; Lat. 62° 55′ S.; Long. 55° 57′ W.; 57 fms. (104 m.); Dec. 21st, 1902; dredged on the Swedish South-Polar Expedition ("Antarctic"), Station 5 and Station 94; several pieces.

Described by K. A. Andersson, 2.

C. aequatus, Andersson.—Nearly related to *C. hodgsoni* and to *C. dodecalophus*. Coenoecium closely resembling that of the latter species, less robust than that of *C. inaequatus* (= *C. hodgsoni*, *vide supra*). Largest piece—120 mm. high; coenoecium containing diatoms in great numbers. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—2·0 mm.; length from bases of arms to end of body—1·1 mm.; width of body—0·7 mm. Colour of zooids preserved in alcohol crimson-brown, fading to pale brown. Arms six pairs in both sexes; axis of each arm with an end-swelling, with refractive beads. Male and female zooids occurring in the same colony, in approximately equal numbers; hermaphrodites (with one ovary and one testis) not known. Testes short. Free ova measuring 0·4 by 0·35 mm., attached by a stalk. Buds two to four on each zooid.

Locality—Graham Region, North of Joinville Island; Lat. 62° 55′ S.; Long. 55° 57′ W.; dredged on the Swedish South-Polar Expedition ("Antarctic"), Station 94; 57 fms. (104 m.); Dec. 21st, 1902; a few pieces.

Described by K. A. Andersson, 2.

C. gracilis, Harmer.—Colony very small and delicate, irregularly branched; the single specimen known of prostrate habit, supported by calcareous foreign objects (branches of the Polyzoan *Tubucellaria*). Width of branches—1·0 to 1·5 mm. Coenoecium almost colourless, the orange-coloured zooids within imparting a yellow tint to the colony. Cavity of coenoecium continuous, occupied in common by the zooids and their buds. Ostia at the ends of the branches, funnel-shaped, 0·8 mm. across; margin produced into three, four or five spines; length of spines on the average—2 mm., rarely as much as 4 mm.; width of spines—0·16 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—1·3 mm.; length from bases of arms to end of body—0·8 mm.; width of body—0·4 mm. Colour (of preserved

zooids) orange, stalk with black pigment in the median line of the anterior surface. Arms five pairs; small end-swellings, with refractive beads, on the first pair of arms of the bud, and occasionally on second and third pairs also, sometimes persisting in the adult. Testes—(male zooids not known). Free ova 0·3 to 0·4 mm. in length, not stalked. Buds in great profusion on the zooids.

Locality—East coast of Borneo; Lat. 0° 34·6′ N.; Long. 119° 8·5′ E.; obtained on the "Siboga" Expedition, Station 89; on coral-reef between tide-marks; June 21st, 1899; one piece.

Described by S. F. Harmer, 10.

C. sibogae, Harmer.—Colony very small and delicate, orange-coloured (in alcohol), irregularly branched; size of the single specimen known—21 mm. high, 34 mm. wide, with a dense basal encrusting part of the coenoecium attached to a stone; coenoecial substance with numerous foreign inclusions. Width of a branch—1·0 to 1·5 mm. Cavity of coenoecium continuous, occupied in common by the zooids and their buds. Ostia at the ends of very short side-branches, more or less alternate on opposite sides of the branch, funnel-shaped, 0·5 mm. across; margin produced into two or three spines; length of spines—0·8 to 1·5 mm.; width—0·12 mm. Zooids—females not known. Free ova not known. Neuter zooids—length from free ends of the arms to end of body—1·3 mm.; length from bases of arms to end of body—0·8 mm.; width of body—0·3 mm. Colour blackish. Arms four pairs, no end-swellings with refractive beads. Buds in great profusion. Male zooids with conical body, passing continuously into the stalk; alimentary canal vestigial; testes long, occupying most of the trunk; arms one pair, without tentacles, surface with crowded refractive beads, at least in young males; colour blackish. Zooids having the same general structure as the neuters sometimes found with functional testes.

Locality—Northern entrance of Buton Strait, off S.E. of Celebes; Lat. 4° 20′ S.; Long. 122° 58′ E.; dredged on the "Siboga" Expedition, Station 204; 41–51 fms. (75–94 m.); Sept. 20th, 1899; one piece.

Described by S. F. Harmer, 10.

SUB-GENUS *IDIOTHECIA*, Ridewood.

Sub-genus *Idiothecia*, Ridewood.—Colony branching. Each ostium of the coenoecium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common coenoecial substance, and disposed at a more or less constant angle to the surface; either blind at their inner ends, or connected up in the middle of the branch.

C. agglutinans, Harmer and Ridewood.—Colony massive, branching; largest pieces known measuring 100–115 by 45–55 mm.; width of a main stem—20 to 45 mm.; width of a single branch—10 to 25 mm. Coenoecium friable, cream-coloured,

speckled, opaque, containing large quantities of shells of Foraminifera, fragments of shells of Mollusca and spines of Echinoids, and rounded particles of slate. No peristomial tubes; each ostium with a single thick lip or spine, that projects about 3 mm. beyond the general surface. Average distance from one ostium to that nearest it—3 or 4 mm., but less at the free extremity of the branch. Each ostium leading into a tube that communicates at its inner end with a tubular labyrinth in the middle part of the branch. Width of cavity of the tubes—1·0 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—4·5 mm.; length from bases of arms to end of body—3·2 mm.; width of body—0·8 mm. Colour (of preserved zooids) blackish. Arms eight or nine pairs, no end-swellings with refractive beads. Testes long. Females and hermaphrodites not known. Free ova not known. Buds on each zooid many, up to seven pairs; late buds, with more than five pairs of arms, not known.

Locality—Burdwood Bank, South of Falkland Islands; Lat. 54° 25′ S.; Long. 57° 32′ W.; dredged by the "Scotia" on the Scottish National Antarctic Expedition of 1902–1904, Station 346; 56 fms. (102 m.); Dec. 1st, 1903; several pieces.

Described by S. F. Harmer and W. G. Ridewood, 11.

C. gilchristi, Ridewood.—Colony of fairly long branches, some of the branches connected across by solid bars; maximum size of known specimens—190 mm. by 110 mm.; distance from one branch to the next—30 mm. on an average, maximum 55 mm., minimum 17 mm.; width of terminal branches, not including spines, about 5 to 8 mm.; width of basal stems about 10 mm. Colour brown or pale brown. Ostia numerous, except on the main stems; mostly sessile, but those on terminal branches with short, rarely long, peristomial tubes. Each ostium leading into a tube that ends blindly in the middle part of the branch. Width of cavity of the tubes—1·0 to 1·2 mm.; length—3 to 5 mm. Spine-like processes of the coenoecium numerous, slender, simple, occasionally forked; on an average one spine in relation with each tube, alongside which it can be traced for some distance into the interior of the branch; length of the freely projecting portion of each spine about 10 mm.; width—0·3 to 0·4 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—1·6 to 1·8 mm.; length from bases of arms to end of body—1·0 to 1·2 mm.; width of body—0·7 to 0·8 mm. Colour when alive blackish, with colourless arms; colour of preserved zooids brown, with a broad blackish margin to the anterior part of the shield. Arms usually six pairs; no end-swellings with refractive beads. Male and female zooids occurring in the same colony; hermaphrodites not known. Testes globular or pear-shaped. Free ova about 0·4 mm. across, sometimes attached by a short stalk. Buds two to five on each zooid.

Localities—Off Cape St. Blaize, Knysna Heads, Cape St. Francis, East London, and other localities on the South coast of Cape Colony, South Africa, within a range of Lat. 33°–35° S.; Long. 22°–28° E.; dredged by a Cape Government trawler under

Dr. J. D. F. Gilchrist, from depths varying from 29 to 130 fms. (53 to 238 m.); during the years 1900–1904; many pieces.

Described by W. G. Ridewood, 16.

Material of *C. gilchristi* has since been obtained, mainly from Mossel Bay; see J. Stuart Thomson, "Nature," Nov. 5th, 1914, p. 273; and J. D. F. Gilchrist, 3 and 4.

C. levinseni, Harmer.—Colony reddish orange, slightly branched, size of the single specimen known—132 mm. high; width of a branch, not including peristomial tubes—3 to 5 mm.; width including peristomes about 12 mm.. Ostia numerous, each leading into a tube that ends blindly in the middle part of the branch. Peristomial tubes projecting beyond the general surface about 4·0 mm.; abaxial edge of the peristome ending in a blunt lip which is continued as a ridge or "midrib" down the outer (abaxial) surface of the peristome. Length of the tubes, including peristomial part, about 6·0 mm.; width of cavity—0·6 to 0·7 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—2·5 mm.; length from bases of arms to end of body—1·5 mm.; width of body—0·4 to 0·5 mm. Colour (of preserved zooids) whitish. Arms six pairs; no end-swellings with refractive beads. Testes—(male zooids not known). Free ova measuring 0·3 to 0·4 mm. in length, not stalked. Buds few on each zooid.

Locality—Off the West coast of Japan, at the South end of the Corea Strait; Lat. 32° 10′ N.; Long. 128° 20′ E.; 100 fms. (183 m.); sent to the Copenhagen Museum; one piece.

Described by S. F. Harmer, 10.

C. evansi, n. sp.—Colony massive in build, branching; largest piece known a single branch, 47 mm. high, 19 mm. wide, not including peristomes. Coenoecium friable, cream-coloured, speckled, containing large quantities of shells of Foraminifera and fragments of shells of Molluscs and Echinoids. Ostia at the ends of tubular peristomes that project 2·5 to 4·5 mm. beyond the surface of the branch; ostium set obliquely, sometimes squarely, at the end of the peristome, without definite lip or spine. Each ostium leading into a tube that ends blindly in the middle part of the branch. Width of cavity of the tubes—0·6 to 0·8 mm.; length of tube, including the peristomial part, 10 to 25 mm., but shorter than 10 mm. at the apex of the branch. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—3·5 mm.; length from bases of arms to end of body—2·3 mm.; width of body—0·7 mm. Colour (of preserved zooids) pale green or white, with the red line of the shield very conspicuous. Arms usually eight pairs, sometimes nine or seven pairs; no end-swellings with refractive beads. Male and female zooids occurring in the same colony; hermaphrodite zooids (with one ovary and one testis) not known. Testes long. Free ova not known. Buds several to each zooid, up to nine.

Locality—New Zealand, from summit of Great King, Three Kings Islands, S. 14° W., 8 miles; Lat. 34° 15′ S.; Long. 172° 4′ E.; dredged on the British Antarctic ("Terra Nova") Expedition, Station 90; 100 fms. (183 m.); July 25th, 1911; two pieces.

Described in the present report, pp. 26–31.

C. nigrescens, Lankester.—Colony massive, branching; maximum size of known specimens—190 by 115 mm., with twelve branches; maximum width of a single branch—32 mm., minimum width of a branch—5 to 9 mm.; branches roughly cylindrical, stout branches with rounded or tapering apices; colour greyish, translucent. Ostia at the ends of short, tubular peristomes, but in main stems of the colony frequently sessile; abaxial edge of the peristome produced into a blunt lip, but with no prominent ridge continued downward from the lip. No spines. Each ostium leading into a tube that ends blindly in the middle part of the branch. Width of cavity of the tubes—1·2 to 1·3 mm.; length—12 to 17 mm. on an average, but longer (20 to 26 mm.) in thick stems, and very short (4 to 5 mm.) at the tips of the branches; the deeper parts of the longest tubes shut off by curved septa so that the habitable part of the tube is reduced (commonly 8 to 14 mm. in length). Zooids—length from free ends of the arms to end of body of a fairly extended zooid—4 to 6 mm.; length from bases of arms to end of body—2·5 to 3·5 mm.; width of body—about 0·9 mm. Colour (of preserved zooids) blackish. Arms usually seven pairs, sometimes six or eight pairs; in well-preserved material fixed in formalin solution or in alcohol the tentacles pale and the axis rather broad, with two longitudinal black bands, but in material fixed in picric acid solution, and in badly fixed alcoholic material, the tentacles and axis of a uniform dark brown or black colour; no end-swellings with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony. Testes long. Free ova—0·6 by 0·5 mm. up to 0·9 by 0·7 mm., not stalked. Buds from two to nine on each zooid.

Locality—N.E. coast of Coulman Island, Victoria Land; Lat. 73° 18′ S.; Long. 170° 0′ E.; dredged by the "Discovery" on the National Antarctic Expedition; 100 fms. (183 m.); Jan. 13th, 1902; several pieces.

Described by E. Ray Lankester, 12; and by W. G. Ridewood, 17.

Material of *C. nigrescens* had previously been obtained, but it remained in the British Museum unidentified until it was described by Ridewood (19) in 1912. This material consists of three pieces, which there is reason to believe were dredged on the "Erebus" and "Terror" Antarctic Expedition, in Ross Sea, within 3° longitude of Coulman Island, from a depth of about 300 fathoms (549 m.), either in January 1841 or February 1842.

Material of *C. nigrescens* was obtained on the Second French Antarctic ("Pourquoi Pas?") Expedition, from South of Jenny Island, near Adelaide Island, Graham

Region; Lat. 68° S.; Long. 70° 20′ W. Paris (68° W. Greenwich); 137 fms. (250 m.); Jan. 21st, 1909; many pieces, the largest measuring 120 to 150 mm. in height.

Described by C. Gravier, 8.

Material of *C. nigrescens* was obtained on the Australasian Antarctic Expedition of 1911–1914, from Station 8, off Queen Mary Land; Lat. 66° 8′ S.; Long. 94° 17′ E.; 120 fms. (219 m.); Jan. 27th, 1914; one piece.

Described by W. G. Ridewood, 21.

Material of *C. nigrescens* was obtained on the British Antarctic ("Terra Nova") Expedition of 1910–1913, from McMurdo Sound, Ross Sea, Stations 314, 316, 348 and 355, at depths between 190 fms. (348 m.) and 300 fms. (549 m.), on dates between Jan. 23rd, 1911, and Jan. 20th, 1913; many pieces.

Described in the present report, pp. 31–37.

SUB-GENUS *ORTHOECUS*, Andersson.

Sub-genus *Orthoecus*, Andersson.—Colony not branching, but in the form of a cake, or cone, or mass of irregular shape. Each ostium of the coenoecium leading into a tube which is occupied by one zooid and its buds. The tubes embedded in common coenoecial substance, either for their whole length or towards their blind ends only; either closely set and parallel, more or less vertical, or irregularly bent and straggling.

C. solidus, Andersson.—Colony not branching, in the form of a bulky mass or cake, measuring up to 250 or 300 mm. across, and 100 mm. high; the mass consisting of closely set, vertically disposed tubes of uniform diameter, each with an ostium at the upper end, and terminating blindly below; the tubes pale brown, united, except for a short distance at their upper ends, by common coenoecial substance which may contain sand-grains, fine sponge-spicules and diatoms. The common coenoecial substance moderately firm, like that of *C. nigrescens*, not soft and spongy like that of *C. densus*. Upper end of each tube produced on one side into a short, thick, upright lip. Tubes in the middle of the colony measuring up to 100 mm., those at the sides shorter; width of cavity of tube—1·2 mm.; near the ostium—1·4 mm.; in narrowest parts—1·0 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—4 to 5 mm.; length from bases of arms to end of body—3·0 to 3·5 mm.; width of body—1·0 mm. Colour (of preserved zooids) blackish; but colour of zooids removed from their tubes and preserved in 70 per cent. alcohol, not kept in the dark, fading to raw umber or yellow ochre. Arms usually eight pairs, axes not known to possess the two black bands seen in arms of *C. nigrescens*; no end-swellings with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony.

Testes long. Free ova measuring 0·9 by 0·7 mm., not stalked. Buds many to each zooid, up to fourteen.

Locality—Graham Region, North of Joinville Island; Lat. 62° 55′ S.; Long. 55° 57′ W.; dredged on the Swedish South-Polar Expedition ("Antarctic"), Station 94; 57 fms. (104 m.); Dec. 21st, 1902; several large pieces were dredged, but only two fragments were saved from the "Antarctic" before it sank.

Described by K. A. Andersson, 2.

Material of *C. solidus* was obtained on the Australasian Antarctic Expedition of 1911–1914, from Station 2; off Mertz Glacier, Adélie Land; Lat. 66° 55′ S.; Long. 145° 21′ E.; 318 fms. (582 m.); Dec. 28th, 1913; five pieces.

Described by W. G. Ridewood, 21.

C. densus, Andersson.—Colony not branching, in the form of a bulky mass or cake, measuring up to 70 mm. high and 95 mm. across (Swedish Expedition material), and 100 mm. high and 130 mm. across ("Terra Nova" Expedition material); the mass consisting of closely set. vertically disposed tubes of uniform diameter, each with an ostium at the upper end, and terminating blindly below; the tubes sometimes straggling, not closely set, nor straight. The tubes united by common cocnoecial substance for a part of their length, particularly near their bases. The common coenoecial substance very soft and spongy, and liable to disintegration, unlike the more gelatinous substance of *C. solidus* and *C. nigrescens*. Ostium set transversely, rarely obliquely, to the end of the tube, the margin without lip, uniform, thin, sometimes with irregular external flanges. Tubes colourless, or pale brown; sometimes encrusted with sand-grains or diatoms; measuring up to 60 or 70 mm., perhaps more, in the middle of the colony, towards the edges gradually shorter; width of cavity of tube—1·0 to 1·2 mm., slightly greater near the ostium; external diameter of free part of a tube about 1·6 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid —4 to 7 mm.; length from bases of arms to end of body—2 to 4 mm.; width of body—0·8 to 1·0 mm. Colour (of preserved zooids) greyish white, ochreous, orange or brown. Arms usually eight pairs; no end-swellings with refractive beads. Male and female zooids and hermaphrodites (with one ovary and one testis) occurring in the same colony. Testes long, elongate pyriform. Free ova measuring 0·8 by 0·7 mm., not stalked. Buds many to each zooid, from five to fourteen.

Locality—Graham Region, S.E. of Seymour Island; Lat. 64° 20′ S.; Long. 56° 38′ W.; dredged on the Swedish South-Polar Expedition ("Antarctic"), Station 5; 82 fms. (150 m.); Jan. 16th, 1902; a few pieces.

Described by K. A. Andersson, 2.

The material described by Andersson (2) as *C. rarus* is by the present writer regarded as belonging to the species *C. densus*. For localities see *C. rarus* (*infra*).

Material of *C. densus* was obtained on the Australasian Antarctic Expedition of 1911–1914, from Station 8; off Queen Mary Land; Lat. 66° 8′ S.; Long. 94° 17′ E.; 120 fms. (219 m.); Jan. 27th, 1914; one piece.

Described by W. G. Ridewood, 21.

Material of *C. densus* was obtained on the British Antarctic ("Terra Nova") Expedition of 1910–1913, from McMurdo Sound, Ross Sea, Stations 314, 316, 339, 355 and 356, at depths between 50 fms. (92 m.) and 300 fms. (549 m.); on dates between Jan. 23rd, 1911, and Jan. 22nd, 1913; several pieces; also from Ross Sea, E.S.E. of Coulman Island, Station 295; Lat. 73° 51′ S.; Long. 172° 57′ E.; 190 fms. (348 m.); Jan. 27th, 1913; several pieces.

Described in the present report, pp. 37–48.

C. rarus, Andersson.—*Cephalodiscus rarus* is regarded by the present writer as not specifically distinct from *C. densus*. See pp. 39–40 of this report.

Localities—Graham Region, S.W. of Snow Hill Island; Lat. 64° 36′ S.; Long. 57° 42′ W.; 68 fms. (125 m.); Jan. 20th, 1902; and North of Joinville Island; Lat. 62° 55′ S.; Long. 55° 57′ W.; 57 fms. (104 m.); Dec. 21st, 1902; dredged on the Swedish South-Polar Expedition ("Antarctic"), Station 6 and Station 94; two pieces from the latter station, and a fragment from the former.

Described by K. A. Andersson, 2.

C. anderssoni, Gravier.—*Cephalodiscus anderssoni* is stated by Gravier (8, p. 85) to be closely allied to *C. rarus*, differing from it in the tubes being less independent and isolated. The present writer doubts whether *C. anderssoni* is specifically distinct from *C. densus*.

Colony in the form of a ragged, bulky mass, measuring up to 105 mm. across and 125 mm. high, the mass consisting of not very closely set, radially disposed tubes of uniform diameter, each with an ostium at the upper or outer end, and terminating blindly below or towards the middle of the colony; the tubes comparatively free in their outer parts, in their basal parts cemented by soft common coenoecial substance in groups of four or five, sometimes more; the bases of the groups all cemented into a central basal mass of irregular form. Ostium set transversely, sometimes obliquely, to the end of the tube; the margin without definite lip, uniform, thin. The tubes partly encrusted with sand-grains; measuring up to 70 mm. in the middle of the colony, those at the sides shorter; external diameter of the free parts of the tubes—1·5 to 1·7 mm.; width of cavity of tube about 1·1 mm. Zooids—length from free ends of the arms to end of body—4 to 4·5 mm. Colour of zooids not stated; stalk slightly pigmented, shield pigmented, except the posterior lobe. Arms in buds up to six pairs; number in adults doubtful owing to poor state of preservation of the material; no end-swellings. Female zooids and hermaphrodites (with one ovary and one testis) occurring in the same

colony; males not found. Testes—length not stated. Free ova measuring 1·0 to 1·1 mm. by 0·55 to 0·6 mm., not attached by a stalk. Buds three or four, or as many as eight, to each zooid.

Locality—South of Jenny Island, near Adelaide Island, Graham Region; Lat. 68° S.; Long. 70° 20′ W. Paris (68° W. Greenwich); dredged on the Second French Antarctic Expedition ("Pourquoi Pas?"); 137 fms. (250 m.); Jan. 21st, 1909; many pieces.

Described by C. Gravier, 6 and 8.

C. indicus, Schepotieff.—Colony diminutive, in the form of a small round plate; diameter—7 to 10 mm., height—3 to 4 mm.; bright orange when fresh, but pale when preserved in alcohol. Ostia with slight marginal projections and folds, but without definite peristome or lip; ostia eight to fifteen in number, all on the upper surface, each leading into a tube that is blind at its lower end. Width of cavity of tube—0·7 mm. Zooids—length from free ends of the arms to end of body of a fairly extended zooid—2·2 mm.; length from bases of arms to end of body—1·1 mm.; width of body—0·7 mm. Colour (of preserved zooids) pale, shield slightly pigmented. Arms three pairs, no end-swellings with refractive beads. Male and female zooids occurring in the same colony, hermaphrodites not known. Testes long. Free ova not stalked, size not stated. Buds several to each zooid.

Localities—Bay of Belligemma (Weligama), on South coast of Ceylon; Lat. 5° 35′ N.; Long 80° 16′ E.; collected from coral-reefs in the coast-zone; 5½ to 8 fms. (10 to 15 m.); in the spring of 1908; four pieces. Also from Mahé, Malabar coast of India; Lat. 11° 25′ N.; Long. 75° 21′ E.; collected on the great barrier-reef; 8 to 11 fms. (15 to 20 m.); in the spring of 1908; one piece.

Described by A. Schepotieff, 22.

SUMMARY.

Of the four species of *Cephalodiscus* collected on the expedition one is new to science, and to it is given the name *C. evansi*. See pp. 26–31.

The material of *Orthoecus* collected goes to show that what has been described as *C.* (*O.*) *rarus* (Andersson, 2) is but a lax and straggling form of *C.* (*O.*) *densus*. See pp. 39–40.

In the abundant material of *C. hodgsoni* collected two forms may be distinguished, designated respectively Form A and Form B; they merge insensibly the one into the other, and cannot be regarded as distinct species or even varieties. See pp. 51–57.

A list is given of all recorded specimens of *Cephalodiscus*. See pp. 66–77.

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PLATE I.

Cephalodiscus nigrescens.

Fig. 1.—*Cephalodiscus nigrescens.* Station 348. Nat. size.
Fig. 2.—*C. nigrescens.* Station 316. Nat. size.
Fig. 3.—*C. nigrescens.* Station 348. Nat. size.

Photographs by Mr. C. Butterworth (Figs. 1 and 3) and Mr. H. G. Herring (Fig. 2).

G. M. Woodward del. et lith.

Huth imp.

Cephalodiscus, Pl. I.

PLATE II.

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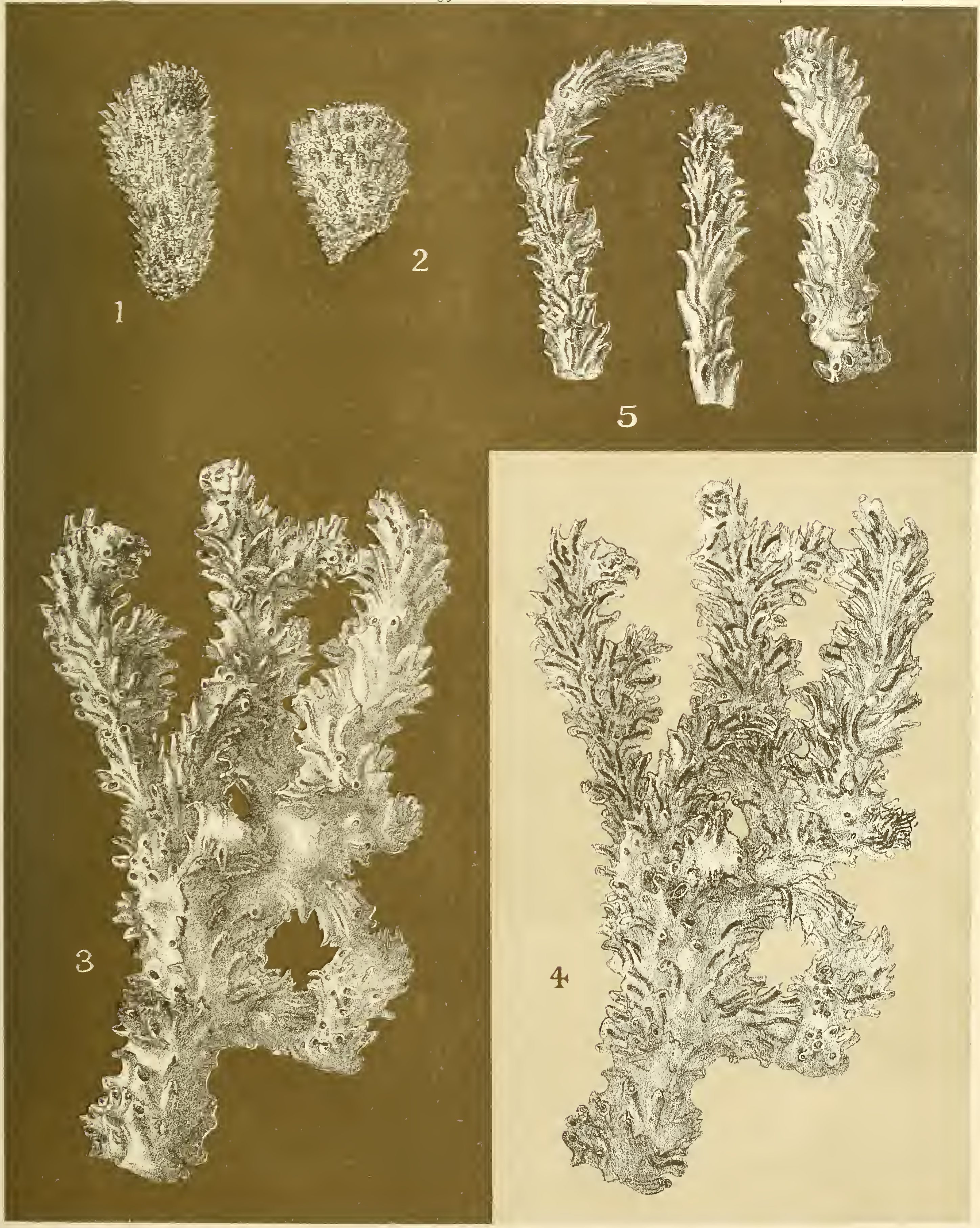
Photographs by Mr. C. Butterworth (Figs. 1, 2, 4 and 5) and Mr. H. G. Herring (Fig. 3).



G. M. Woodward del. et. lith.

Huth. imp.

PLATE III.

Cephalodiscus densus.

Figs. 1–5.—*Cephalodiscus densus*, rather lax fragments of colony. Station 316. Nat. size.
Fig. 6.—*C. densus*, a complete, dense, cake-like colony. Station 356. Nat. size.

Photographs by Mr. C. Butterworth.

G. M Woodward del.

PLATE IV.

Cephalodiscus hodgsoni, Forms A and B.

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FIG. 2.—*C. hodgsoni*, Form B. Station 348. Nat. size.
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Photographs by Mr. C. Butterworth (Fig. 1) and Mr. J. H. Leonard (Figs. 2–3).

1.

2.

3.

PLATE V.

FIG. 1.—*Cephalodiscus hodgsoni*, Form A, a long, slender piece of colony. Station 355. Nat. size.

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FIG. 6.—*C. densus*, a small portion of colony, showing external flanges to the tubes. Station 314. Nat. size.

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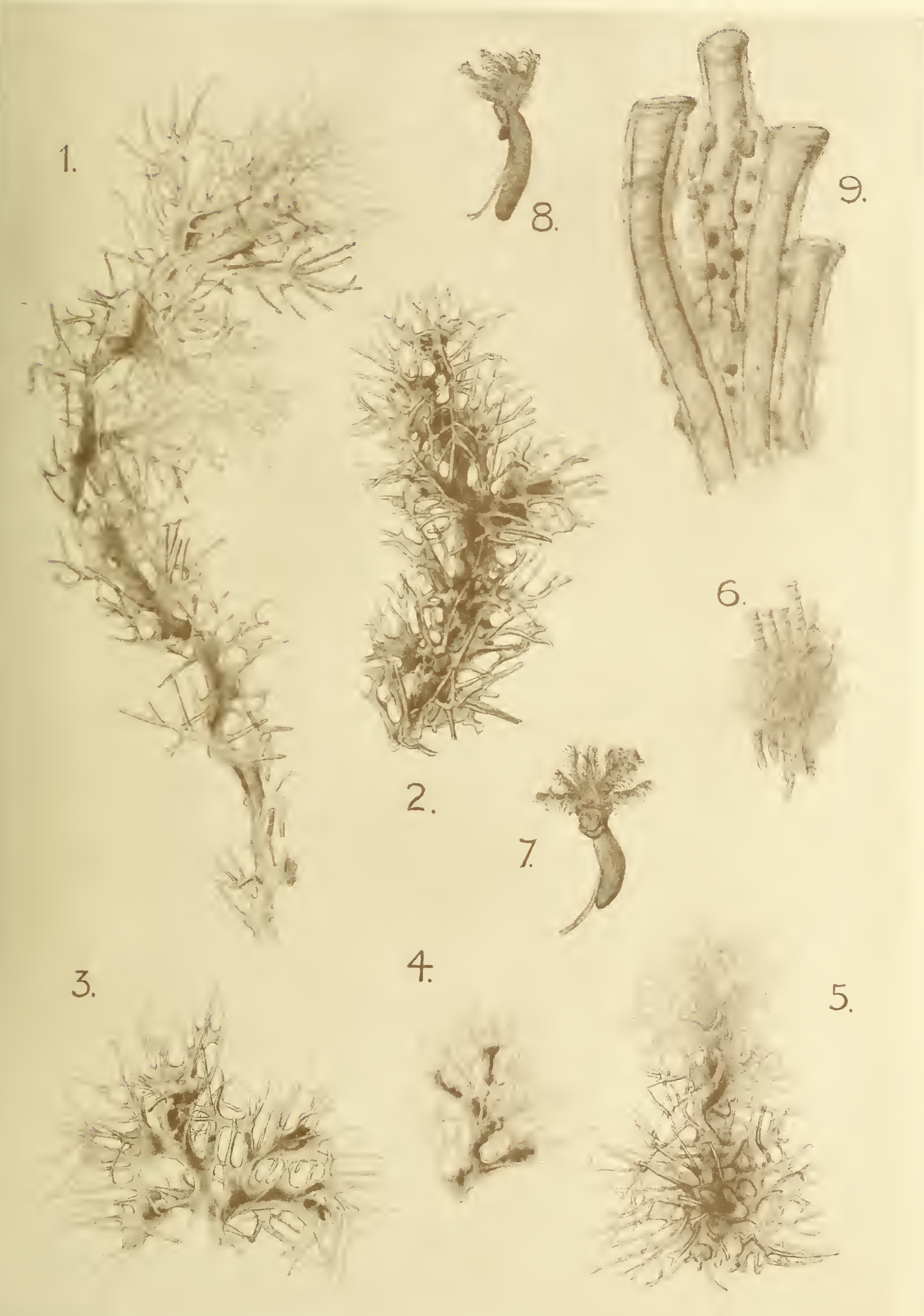
FIG. 9.—*C. evansi*, four tubes partially dissected out. Station 90. Approximately × 8.

Photographs by Mr. C. Butterworth (Figs. 1–2), Mr. J. H. Leonard (Figs. 3–5), and Dr. W. G. Ridewood (Figs. 69) .



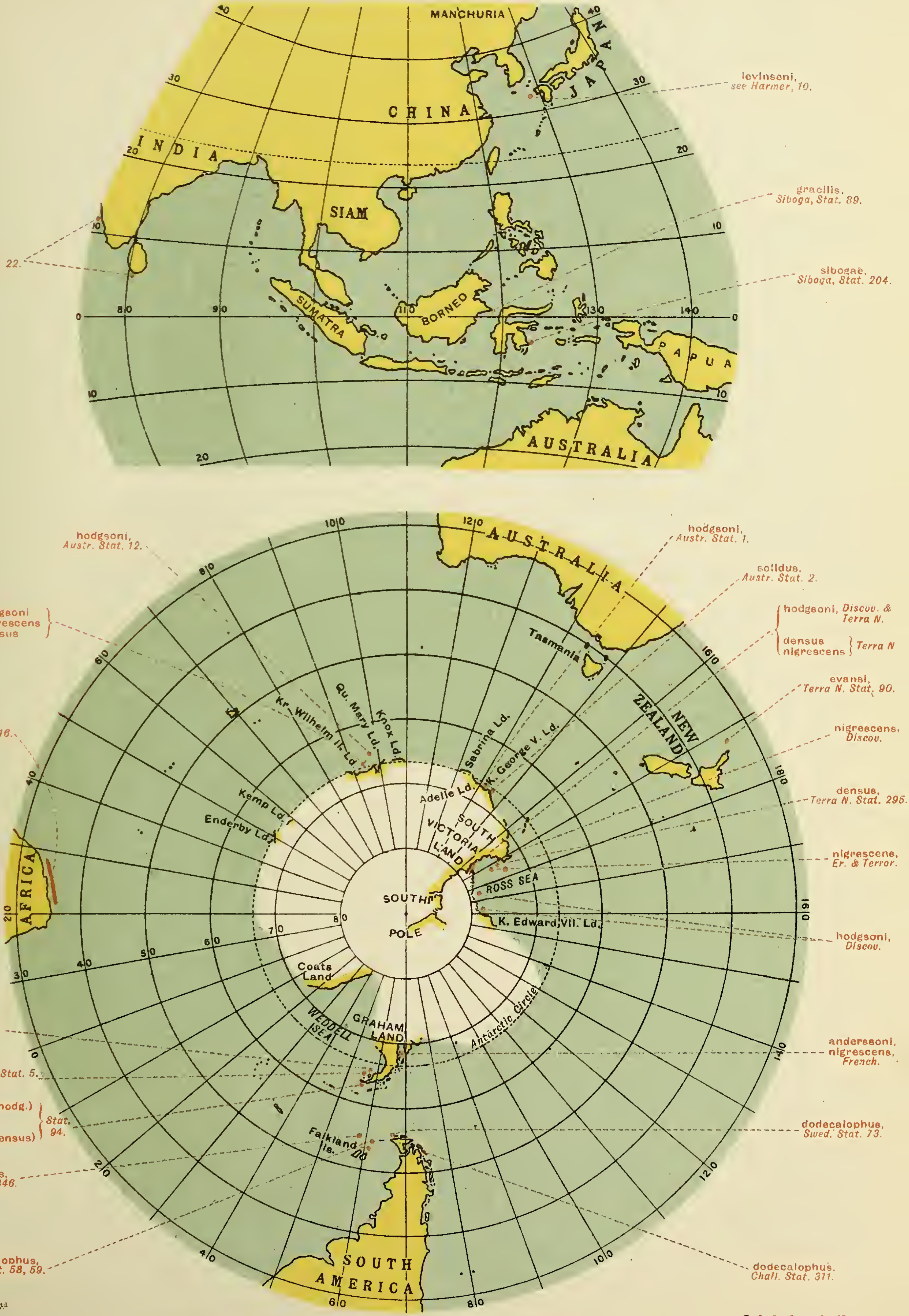
G. M. Woodward del

PLATE VI.

Maps showing the geographical distribution of *Cephalodiscus*; for study in connection with the synopsis of the species at present known, pp. 66–77.

Abbreviations.

Austr.—Australasian Antarctic Expedition, 1911–1914; see Ridewood, 21.
Chall.—"Challenger" Expedition, 1873–1876; see M'Intosh, 14.
Discov.—National Antarctic ("Discovery") Expedition, 1901–1904; see Ridewood, 17.
Er. & Terror.—"Erebus" and "Terror" Antarctic Expedition, 1839–1843; see Ridewood, 19. The exact locality from which *Cephalodiscus* was obtained is doubtful; in the map two alternatives are given.
French.—Second French Antarctic Expedition, 1908–1910; see Gravier, 8.
Scotia.—Scottish National Antarctic ("Scotia") Expedition, 1902–1904; see Harmer and Ridewood, 11
Siboga.—"Siboga" Expedition in the Dutch East Indies, 1899–1900; see Harmer, 10.
Swed.—Swedish South Polar Expedition, 1901–1903; see Andersson, 2.
Terra N.—British Antarctic ("Terra Nova") Expedition, 1910–1913; see Ridewood, the present report.



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ECHINODERMA (PART II.) AND ENTEROPNEUSTA.

LARVAE OF ECHINODERMA AND ENTEROPNEUSTA.

BY

E. W. MacBRIDE, D.Sc., LL.D., F.R.S.

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ECHINODERMA (PART II.) AND ENTEROPNEUSTA.

LARVAE OF ECHINODERMA AND ENTEROPNEUSTA.*

BY E. W. MACBRIDE, D.Sc., LL.D., F.R.S.,

Professor of Zoology in the Imperial College of Science and Technology, London, S.W.

WITH TWO PLATES.

I.—INTRODUCTION.

THROUGH the kindness of my friend Dr. S. F. Harmer, F.R.S., Director of the Natural History Departments of the British Museum, I obtained the privilege of examining and reporting on the Echinoderm and Enteropneust larvae brought back by the "Terra Nova" Expedition.

A considerable number of specimens were collected; but they all belong to four species, of which only one, a *Bipinnaria*, is new. Two species of *Auricularia* are

* Manuscript received July 24, 1918 [S. F. H.].

represented in the collection, and one of *Tornaria*. Of one of the species of *Auricularia*, specimens in different stages of growth were obtained, and I was thereby enabled to settle some disputed points in the embryology of Holothurioidea which are of general interest. As Mr. Simpson and myself (8) had formerly described Echinoplutei and Ophioplutei from the same part of the world, all four types of Echinoderm larvae have now been recorded by me from this region of the Antarctic.

II.—DISTRIBUTION.

The specimens were captured at two groups of stations, the members of each group being close to one another, so that all the larvae are derived from two localities, of which only one was Antarctic. The other locality is in the vicinity of Three Kings Islands, a group of islets situated a short distance north of North Cape, New Zealand. In this second locality the *Tornaria* and one of the species of *Auricularia* (*A. nudibranchiata*) were obtained. The Antarctic locality comprises a group of stations situated between 69° 50′ and 72° S., and between 166° and 168° 50′ W. The area within which these stations lie is therefore roughly a rectangle of two-and-a-half degrees of longitude in width, and of two-and-a-half degrees of latitude in height.

III.—PRESERVATION AND METHODS OF PREPARATION.

In all the bottles, except one, which were handed over to me, the larvae were contained in formalin solution. In one case the specimens had been placed in picric acid, but they were in fragments when the bottle came into my hands. All the larvae, therefore, which I was able to examine, had been preserved in formalin.

This circumstance had a determining influence on the methods of preparation which I adopted. It is a well-known fact that formalin gives poor results so far as histological structure is concerned, but that it renders the tissues very transparent. Hence all the specimens which I examined were stained in bulk and mounted whole. Two stains were employed, both in strong alcoholic solution, *viz.*: eosin and light green. The latter, which, like eosin, is an aniline dye, gave far more satisfactory results than eosin because it produced a much more intense coloration. After being stained the specimens were transferred to absolute alcohol, to which a few drops of oil of cloves were added every day for a couple of weeks. Then the mixture of oil and alcohol was placed in an open vessel and allowed to evaporate, and, as a result, in a couple of days only pure oil of cloves remained. To this an equal amount of solution of Canada balsam in Xylol was added, and in this mixture the specimens were left for a day, after which they were ready to be transferred to pure balsam on the slides. It is to be noted that formalin readily becomes partially oxidized to formic acid, and so any calcareous structures which the specimens originally contained had been dissolved before they came into my hands.

IV.—DESCRIPTION OF THE SPECIES.

ECHINODERMA.

A. HOLOTHURIOIDEA.

1. *Auricularia antarctica*, MacBride. Figs. 1–3, 5, 6.

Station 270. 69° 51′ S., 166° 17′ W., surface to 600 metres. Two large specimens.
,, 272. 71° 35′ S., 166° 11′ W., 80 metres. Several specimens.
,, 274. 71° 29′ S., 166° W., 80 metres. Many specimens.
,, 275. ,, ,, 160 metres. Many specimens.
,, 281. 71° 41′ S., 166° 47′ W., 80 metres. Many specimens.
,, 283. 71° 39′ S., 166° 47′ W., 80 metres. Many specimens.
,, 285. 71° 49′ S., 167° 32′ W., surface to 600 metres. Two large specimens.
,, 288. 71° 59′ S., 168° 43′ W., 60 metres. Many specimens.

This species was originally described by me from a single specimen (9). It was subsequently found by Mortensen amongst the larvae collected by the German South Polar Expedition (14). In the collection which is the subject of the present memoir it is represented by numerous specimens of all sizes, from about ·8 mm. to 5·0 mm. in length.

The diagnostic characters of *A. antarctica* as originally determined by me were three : *viz.* (1) The presence of numerous calcareous "wheels" ; (2) the great extension of the post-oral loop of the longitudinal ciliated band, which goes so far forward that it is separated from the prae-oral loop by a narrow groove in which the mouth lies ; (3) the great width of the larva from front to back (Fig. 2), as a result of which the anterior pole, *i.e.*, the spot where the prae-oral loop leaves the main portion of the longitudinal ciliated band, is situated far behind the mouth instead of being directly anterior to it, as is the case with most *Auricularia* larvae. To these characters I can now add a fourth : *viz.*, the intestine is produced into two well-developed pouches directed ventrally, between which the ventral curvature of the stomach is contained. These pouches (*int. l.*) are well seen in Figs. 3, 2, and 6.

The characteristic calcareous "wheels" had been dissolved by the acidity of the preserving fluid, but the other two characteristics are very strongly marked, and quite sufficient to determine these larvae as belonging to *A. antarctica.* In many of the specimens little disc-shaped groups of cells can be made out (*calc.*, Figs. 1 and 3) which represent the organic bases of the vanished "wheels."

The exact mode of development of the coelom in Holothurioidea has been the subject of considerable differences of opinion. The older authors described its first beginning as a sac given off from the blind apex of the archenteron, as in other groups of Echinoderms (Selenka, 17, 18). This sac speedily acquired a communication with the exterior by the development of a tubular extension, the PORE-CANAL, which fused with the dorsal ectoderm. In some species, at any rate, the pore-canal was developed before the alimentary canal had been completed by the union of the stomodaeum with the archenteron.

According to Selenka (18) and Metschnikoff (10) the coelomic sac then became divided into anterior and posterior portions, of which the former gave rise to the HYDROCOELE or rudiment of the water-vascular system, whilst the latter became divided transversely into two parts which became applied to the right and left sides of the alimentary canal, and constituted the posterior coelomic sacs of the larva (Fig. 5, *r. p. c.*, *l. p. c.*). The critical stages in which the posterior portion of the single sac became changed into right and left posterior coelomic sacs were first figured by Metschnikoff (10).

Bury, who examined stages in the development of the larva of *Synapta digitata* (1), came to a different conclusion as to the manner in which the coelomic sac developed. According to him, when it has become divided into anterior and posterior portions the anterior division does not become directly converted into the hydrocoele. The hydrocoele on the contrary grows out as a bud from its hinder aspect, which remains connected with the main sac, termed by Bury the ANTERIOR COELOM. The narrow neck of connection between hydrocoele and anterior coelom was identified by him with the PRIMARY STONE-CANAL. Bury compared the anterior coelom of *Synapta* to the axial sinus of Asteroidea, and surmised that it gave rise to the "internal madreporite" of the adult Holothuroid.

Bury's view has not been confirmed by subsequent workers. Ludwig (5) examined the development of *Cucumaria planci*, and came to the conclusion that the anterior portion of the primitive coelomic sac was directly converted into the hydrocoele; in later stages he found what he termed an "ampulla," *i.e.*, a thin-walled expansion on the course of the pore-canal; but he maintained that this was a secondary formation. Newth (15), who worked at *Cucumaria saxicola*, came to much the same conclusion. Clarke (3), who studied the development of *Synapta vivipara*, also describes the anterior division of the coelomic sac as being directly converted into the hydrocoele. Now it is to be remembered that *Synapta digitata* is the only species of Holothuroid with a typical larva, the complete life-history of which has been worked out.

The species of *Cucumaria* have yolky eggs, with shortened life-histories, and larvae which do not show the features of an *Auricularia*; whilst the young of *Synapta vivipara*, as the name of the species implies, develop into the adult form inside the maternal body. We are therefore permitted to surmise either that the observers who worked with these rapidly developing eggs overlooked stages which Bury was able to see in the slowly developing larvae, or else that these stages were actually suppressed in the more modified development. For instance, one might imagine that what Clarke, Ludwig, and Newth regard as a "pore-" or "stone-canal," connecting the incipient hydrocoele with the exterior, might represent the vesicle which Bury terms the anterior coelom in a collapsed form.

Under these circumstances it was a pleasure to me to discover that the specimens of *Auricularia antarctica* in the collection constituted a series from which it was possible to reconstruct the entire history of the coelom. In the youngest specimen the coelom is a simple rounded sac opening to the exterior by a pore-canal. In a specimen

slightly older, such as is shown in Fig. 3, the first rudiment of the hydrocoele (*hy.*) can be made out as a slight thickening on the posterior border of the coelomic sac. In a slightly older larva (Fig. 1) the hydrocoele has not advanced much in development, but from its hinder aspect a small stalked cellular bud can be seen growing out (Fig. 1, *post. c.*). This is the rudiment of the *posterior coelom*. Fig. 2 represents a more advanced larva viewed from the side. In it the hydrocoele has become as large as the anterior coelom (as the primitive coelomic sac may now be termed), and is delimited from it by a constriction (Fig. 2, *hy.*). The posterior coelom has now developed into a long band lying at the side of the stomach. This stage corresponds with that represented in text-fig. 1 in Mortensen's latest paper (14), but Mortensen has quite misunderstood it. He overlooked the rudiment of the posterior coelom altogether, and has figured a sac entirely detached from the anterior coelom as the posterior enterocoele. This sac, which lies above the junction of the stomach and intestine, has nothing to do with the coelom, but is one of the intestinal pouches characteristic of *Auricularia antarctica*. In Fig. 6, a still older larva is represented, seen from the dorso-lateral aspect. The hydrocoele has now begun to curve ventrally round the oesophagus. The rudiment of the posterior coelom shows a constriction tending to divide it transversely into front and hind portions. Of these the first is the rudiment of the left posterior coelom, and the hinder one is the rudiment of the right posterior coelom. This stage, as mentioned above, has been figured by Metschnikoff (10) in his description of the *Auricularia* of *Synapta digitata*, but has not been described in connection with any other *Auricularia*, although Clarke has described it in the EMBRYO of *Synapta vivipara*.

In Fig. 5 is represented a dorsal view of one of the oldest larvae in the collection. The hydrocoele (*hy.*) has now begun to develop thickened lobes, which are the rudiments of the primary tentacles; it is sharply marked off from the anterior coelom (*ant. c.*), with which it is connected by a strongly constricted neck of communication. The two posterior coelomic sacs (*r. p. c.*, *l. p. c.*) have now taken up their definitive positions to the right and left of the stomach.

A peculiar larval nervous system was described by Semon (19) in the larva of *Synapta digitata*. This system consisted of two bands of fibrils running from the corners of the mouth down the grooves which separate the post-oral loop from the main longitudinal portions of the ciliated band. This nervous system is present in *Auricularia antarctica* (Figs. 1 and 2, *l. nerv.*), but it seems to be shorter than in the *Auricularia* of *Synapta digitata*.

It will be seen that my survey of the specimens of *Auricularia antarctica* entirely confirms Bury's account of the development of the coelom in *Synapta digitata*; and this account may therefore, I think, be taken as correctly describing the normal sequence of events in Holothurioidea. We have evidence in other groups of Echinoderms that the normal processes may become profoundly modified as a result of the hurrying on of development, and in this way we may probably account for Clarke's, Ludwig's, and Newth's results.

The question as to which species, or even family, of Holothurioidea *Auricularia*

antarctica belongs is one which is at present insoluble. In my original description (9) I suggested that *Auricularia antarctica* might be the larva of some member of the sub-order Synaptida, since calcareous wheels are characteristic of many genera belonging to that division, though not of *Synapta* itself. Mortensen dissents from this view on the following grounds, *viz.*: (1) Very few Synaptida are recorded from the Antarctic region; (2) *Auricularia antarctica* shows many points of resemblance to *Auricularia nudibranchiata* (*v. infra*), and the latter species is regarded by Mortensen as the larva of one of the Elasipoda (Elpidiida); (3) the Elasipoda sometimes possess "wheels" amongst their calcifications.

When dealing with *A. nudibranchiata* I shall give grounds for regarding its supposed Elasipodan affinities to be entirely unfounded, though I agree with Mortensen in recognising some striking resemblances in structure between these two species of *Auricularia.* I adhere, however, to my original suggestion for this reason. According to Ludwig (6) the wheels of Elasipoda differ from those of Synaptida in having the hub perforated; and on this account he regards them as more primitive structures. Now although I described the wheels of *Auricularia antarctica* as having perforated hubs, yet a renewed examination of the type specimen in the Natural History Museum has convinced me that I was mistaken. What I took for holes appear to be glittering calcareous asperities, and hence Mortensen was right in casting doubt on my original description in regard to this point. But I utterly fail to understand why he states that perforated hubs are unknown, and why he omits to observe that wheels with solid hubs are found in Synaptida only. Had my original statement been confirmed there would have been some ground for a suggestion of Elasipodan affinity. On the ground that a young Holothuroid, which he diagnoses as a Synallactid, was obtained by the German Expedition, Mortensen finally inclines to the belief that *A. antarctica* may be the larva of this form. As no Synallactid is known to have wheels, this suggestion may be regarded as very improbable. Synaptida are burrowing Holothuroids, and must, therefore, in most cases evade the dredge; and the fragments of the two forms already recorded from the Antarctic area probably give no correct suggestion of their abundance. All the specimens of *Auricularia antarctica* were obtained at depths of between 80 to 160 metres below the surface; the parent must, therefore, be an inhabitant of deep water, and the suggestion that it is a mud-inhabiting Synaptid gains in probability.

2. *Auricularia nudibranchiata*, Chun. Fig. 4.

Station 92, from summit, Great King, S. by W., 24 miles (off N. end of New Zealand), surface. One specimen.

In 1896 Chun (2) described a new form of *Auricularia,* of which he captured many specimens in the vicinity of the Canary Islands. This larva was characterised by the extraordinary complication of the ciliated band, the primary processes of which were bent into numerous secondary processes, which gave to the creature the appearance of a Nudibranch mollusc. For this reason Chun bestowed on it the name *Auricularia nudibranchiata.* The larva possessed three other characteristics: (1) It had embedded

in it numerous calcareous wheels; (2) the post-oral loop of the ciliated band extended so far forward that it was separated from the prae-oral loop only by a narrow groove; (3) the intestine was produced into a median ventral pouch extending forward beneath the stomach. Chun described the anterior division of the larval coelom as a large sac with finger-like outgrowths, which he interpreted as the rudiments of the water-vascular canals of the adult Holothuroid.

In 1911 Ohshima (16) described specimens of what he termed "a large Auricularia allied to *A. nudibranchiata*," which he captured off the south coast of Japan. The larvae appear to me to be identical with Chun's species, but to represent a more advanced stage of its development than Chun secured. Ohshima points out that the ramifications of the anterior coelom described by Chun have nothing to do with the lobes of the hydrocoele, for in his larvae the hydrocoele was a clearly defined, thick-walled structure lying at the side of the oesophagus beneath the anterior coelom, with which it was connected by a narrow neck. In a word, the distinction between hydrocoele and anterior coelom, described by Bury in the larva of *Synapta digitata*, is equally clear in *Auricularia nudibranchiata*. The specimen of this remarkable larva captured by the "Terra Nova" Expedition is in an advanced stage of development, and measures at least a centimetre in length, being more than twice the length of Chun's oldest stage. On examining it I was able to confirm Ohshima's account, and to add certain details which are shown in Fig. 4. This figure represents only a portion of the monster, including the hinder part of the oesophagus, the front part of the stomach and the adjacent coelomic sacs. The anterior coelom can be seen to open to the exterior by a ciliated duct, THE PORE-CANAL (*p. c.*), situated at its posterior end. This duct runs along the wall of the coelom for some distance, and gives the impression of having been originally a groove in this wall which has become closed off. This is the way in which a considerable portion of the pore-canal is formed in the larva of *Asterina gibbosa*. In front and ventrally, the anterior coelom communicates with a well-marked hydrocoele, showing the thickened elevations which are the rudiments of its primary lobes.

When the posterior portion of this larva is examined, it is easy to see the structure described by Chun as a median ventral pouch of the intestine. It is, relatively to the size of the larva, of much less size than in the earlier stages described by Chun. Further, in my specimen it is seen not to be a single pouch, but to consist of a pair of closely adpressed pouches which, I have no doubt, are homologous with the intestinal pouches of *Auricularia antarctica*.

On the ground that a single intestinal diverticulum has been described in certain Elasipoda, Chun and Mortensen draw the conclusion that this larva belongs to the Elasipoda. This single diverticulum is supposed to be a rudimentary representative of the gill- (lung-) trees of other Holothurioidea; but the discovery that the pouch is paired deprives this argument of its ground, and *A. nudibranchiata* might be the larva of any Holothuroid with internal gills, if these pouches are the rudiments of gills. There is, however, grave reason for doubting this hypothesis. When examining a collection of post-larval young of Holothuroids from the Antarctic, which almost certainly

belonged to the genus *Cucumaria*, I discovered what appeared to be the rudiment of the gill-trees, which in this genus are extremely well developed. This rudiment, a single pouch-like outgrowth of the intestine, only appeared in the oldest specimens—in the younger there was no trace of it (9). It is, therefore, exceedingly unlikely that a rudiment of these gills should appear in the *Auricularia* larva; they probably only begin to develop when the cloacal function of sucking in and ejecting water has been established. I conclude, therefore, that the intestinal pouches of *A. antarctica* and *A. nudibranchiata* have nothing to do with gills; and, if this be admitted, there is no reason why *A. nudibranchiata*, like *A. antarctica*, should not be the larva of a Synaptid, to which group its wheels naturally ally it.

B. ASTEROIDEA.

3. *Bipinnaria antarctica*, *nov.* Figs. 7, 8.

Station 274. 71° 29′ S., 166° W., 80 metres. 11 specimens.
,, 284. 71° 49′ S., 167° 32′ W., 80 metres. 3 specimens.
,, 290. 72° S., 168° 17′ W., 60 metres. Many specimens.

In the same locality, and at the same depths at which *Auricularia antarctica* was captured, numerous specimens were obtained of a large *Bipinnaria* in various stages of development, ranging from a stage in which no hydrocoele can be detected to one in which not only the lobes of the hydrocoele, but also the aboral spines of the future starfish are well developed. The calcareous matter of these spines had, of course, been dissolved by the acidity of the preservative; but the organic base of the spines remained, and their shapes were consequently well defined in the specimens.

A careful search through Mortensen's synopses of known Echinoderm larvae (12, 13) failed to disclose any species to which this *Bipinnaria* could be referred, and hence I feel justified in creating for its reception a new species, with the name *Bipinnaria antarctica*.

The new species is characterised by long arms, which do not attain, however, the proportionate length of those of the *Bipinnaria* of *Luidia*. Its most distinguishing feature is, however, the *crenulation* of the ciliated band, which is well shown in Figs. 7 and 8. This is a character which has so far been recorded of no species of *Bipinnaria*. It may be compared to the formation of secondary loops on the ciliated band of *Auricularia nudibranchiata*, and of secondary tentacles on the ciliated band of *Tornaria grenacheri* (*v. infra*), but the folding is slighter than in the case of either of these two larvae.

This folding or crenulation of the ciliated band is confined to those portions of its course which are situated on the arms of the larva. Each of these arms has a groove on its surface bordered by ridges which are surmounted by the ciliated band. Underlying the groove are three bands of longitudinal muscle-fibres (Figs. 7 and 8, *long. musc.*), one in the centre and one on each side.

There are two main types of *Bipinnaria* larva which may be termed the *Asterias*-type and the *Luidia*-type respectively. Larvae of the first type have no median ventral

arm in front of the mouth; in their older stages they develop three peculiar club-shaped arms on the region of the prae-oral lobe, between the prae-oral ciliated band and the median dorsal arm. Such larvae are then termed *Brachiolaria*, and they can hold on to the substratum by these new arms. Eventually they fix themselves permanently by means of an adhesive disc situated in the centre of the three extra arms, and the whole front region of the larva is gradually absorbed. Larvae of the second type have a median ventral arm which carries a loop of the prae-oral ciliated band. So far as is known they never develop into *Brachiolaria*, and although the life-history of none of them has been completely worked out, yet the observations of M. C. Delap (4) on the larva of *Luidia* seem to indicate that, when metamorphosis approaches, the hinder portion of the larva containing the stomach and intestine, and surrounded by the circle of arm-rudiments, becomes amputated from the front half and sinks to the bottom as the future starfish, whilst the front half remains swimming.

As an inspection of Fig. 7 demonstrates, *Bipinnaria antarctica* belongs to the *Luidia* type of larvae, for the median ventral arm is well developed, and in the most advanced specimen no trace of *Brachiolaria* arms has appeared.

It will be noticed that each of the aboral plates of the future starfish carries two large conical spines. Now amongst the starfish described by Ludwig (7), in his description of the collection brought back from Cape Horn and Antarctic waters by the "Belgica," there occurred a species of the genus *Cheiraster* on which Ludwig bestowed the name *C. gerlachei*. Some very small specimens of this species were obtained, which must have metamorphosed only a short time before. In these young starfish the terminal plates covering the tips of the arms each bear two large conical spines resembling those borne by *Bipinnaria antarctica*. Although *Cheiraster gerlachei* was obtained in longitude 82 W., it was found at about the same latitude (about 70° S.) as the larvae; and as between the two localities there extends a comparatively short stretch of open Antarctic sea, it is quite likely that *Cheiraster gerlachei* inhabits the whole of this area, and therefore we may assign *Bipinnaria antarctica* to this species. *Cheiraster* belongs to the family Archasteridae, which is closely allied to the Astropectinidae to which *Luidia* belongs, and it is practically certain that it must have a larva of the *Luidia* type.

ENTEROPNEUSTA.

4. *Tornaria grenacheri*, Spengel. Figs. 9, 10.

Station 130, off Three Kings Islands, N. end of New Zealand, surface. Two specimens.

Two specimens of a species of *Tornaria* were obtained by the Expedition in a haul made in the vicinity of Three Kings Islands, *i.e.*, in the same neighbourhood as that in which *Auricularia nudibranchiata* was obtained. One specimen was in process of metamorphosis, but the other was in the height of larval development, although unfortunately somewhat mutilated. The metamorphosing specimen is shown in Fig. 10.

It will be seen that the longitudinal ciliated band has almost entirely disappeared, but that the strong posterior transverse ciliated band has persisted. From an examination of the longitudinal ciliated band in the mutilated specimen, and of the vestiges of it in the metamorphosing larva, it is clear that this band was produced into secondary tentacle-like processes. It can also be seen that the stomach (*stom.*), instead of being, as in other species of *Tornaria*, a globular sac, is an elongated tubular organ. Now in respect of both these organs this larva agrees with a species termed by Spengel (20) *T. grenacheri*, which was captured in mid-Pacific, between the Sandwich and Marshall Islands, and we may therefore assign our larva to this species. Spengel gives the name *grenacheri* to the species because he regards it as absolutely identical with a larva captured by Prof. Grenacher, near the Cape Verde Islands in the South Atlantic; he also asserts that it is identical with a *Tornaria* first recorded by Weldon (21) from the Bahamas, the development of which was subsequently worked out by Morgan (11), who terms it the Nassau larva. Spengel also mentions that an extremely similar larva was captured by Driesch in the Indian Ocean. If all these larvae really belong to the same species, we should have to infer the existence of an Enteropneust worm with a distribution encircling the earth. When, however, we consider that *Auricularia nudibranchiata* has been captured both in the South Atlantic and the South Pacific, we see that it too must belong to some Holothuroid with an equally wide distribution. Now both Synaptida (wheel-bearing Holothurioidea) and Enteropneusta are creatures which burrow in sand and mud, and on bottoms like these at considerable depths, conditions must be extraordinarily uniform over enormous ranges, so that we should expect the species inhabiting them to be equally widely distributed. There is, therefore, nothing inherently improbable in Spengel's theory; but there are one or two points in the structure of the larva which we are discussing which make me doubt whether it is identical with the Nassau larva, although that larva doubtless belongs to an allied species. When we examine Morgan's figures we observe that the stomach in the Nassau larva, although elongated, is not so tubular as in the typical *T. grenacheri*. Moreover, Morgan figures in the metamorphosing Nassau larva the rudiments of the first gill-pouches, but no trace of a notochord. In our specimen no trace of gill-pouches can be detected, but a well-marked diverticulum is seen to arise from the oesophagus. The tip of this pouch (*nch.*) curves back towards the base of the anterior coelom or proboscis-cavity (*ant. c.*), and I think there can be no doubt that this is the rudiment of the notochord (Fig. 10). It appears more probable therefore that *T. grenacheri* and the Nassau larva belong to two distinct but allied species.

Fig. 9 is intended to elucidate a point in the anatomy of the *Tornaria* larva, of which I can find no clear account either in Spengel's or in Morgan's descriptions.

It is well known that in the adult Enteropneust there is a structure which has been variously termed "glomerulus" or "proboscis-gland." This is a modification of the epithelium of the posterior or basal wall of the proboscis-cavity, where this is indented by the notochord. The cells in this area become thickened and are richly supplied with blood-vessels, and it has been surmised with much probability that the

whole structure is an excretory organ. What seems clearly to be the beginning of this organ is shown both in Fig. 9 and Fig. 10 (*gl. ep.*).

In Fig. 9 the neighbourhood of the proboscis-pore (*d. p.*) is shown on an enlarged scale. It will be seen that the proboscis-cavity is prolonged into two postero-dorsal tubes or "horns" (*r. h.* and *l. h.*), of which only the left communicates with the exterior by the proboscis-pore. Beneath the right horn lies the completely closed pericardial sac (*per.*), which in life is contractile. The analogy of the proboscis-pore and the adjacent pericardial sac to the madreporic pore and the madreporic vesicle of Echinoderms (which in the *Bipinnaria* larva is contractile) has often been pointed out. Beneath the pericardium is a blood-space (Fig. 9, H) which becomes the heart of the adult; the roof of this space is formed by the contractile floor of the pericardial sac. Around this blood-space there is a crescentic mass of deeply-staining and obviously glandular tissue, which must be a modification of the ventro-lateral walls of the pericardial sac. To this structure I propose to give the name of HEART-GLAND (Fig. 9, *h. gl.*). The only reference to it in the works of Morgan and Spengel which I can find is a statement that the cells forming the lateral walls of the pericardial sac become "pear-shaped," and they seem to regard the structure as the first rudiment of the proboscis-gland; but the complete distinctness of the two structures is obvious from an inspection of either Fig. 9 or Fig. 10. We can only surmise that the heart-gland has some function in connection with the blood, and perhaps is an organ of internal secretion.

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PLATE 1.

Auricularia antarctica	Figs. 1–3, 5, 6.
,, *nudibranchiata*	Fig. 4.

List of Abbreviations employed.

a. d. antero-dorsal process of ciliated band.
ad. cil. adoral ciliated band.
an. anus.
ant. c. anterior coelom.
calc. cells forming organic basis of calcification.
hy. hydrocoele.
int. intestine.
int. d. intermediate dorsal process of ciliated band.
int. l. intestinal lobe.
l. nerv. larval nervous system.
l. p. c. left posterior coelom.
m. mouth.
m. p. madreporic pore.
oes. oesophagus.
p. c. pore-canal.
p. d. postero-dorsal process of ciliated band.
p. l. postero-lateral process of ciliated band.
p. o. post-oral process of ciliated band.
post. c. posterior coelomic sac.
pr. o. prae-oral process of ciliated band.
r. p. c. right posterior coelom.
stom. stomach.

The figures are described in the order of the ages of the larvae represented.

Fig. 3.—Ventral view of a young *Auricularia antarctica*, showing the first stages in the development of the hydrocoele (*hy.*); *calc.* organic bases of calcification. Magnification 22 diameters.

Fig. 1.—Oblique ventral view of a somewhat older specimen of *A. antarctica*; *l. nerv.* larval nervous system; *post. c.* a bud of cells, growing from the posterior border of the hydrocoele, which is the first rudiment of the posterior coelomic sac. Magnification 22 diameters.

Fig. 2.—A still older specimen of *A. antarctica* viewed from the left side; *int. l.* lobes of the intestine. The hydrocoele (*hy.*) is a large sac separated from the anterior coelom (*ant. c.*) by a constriction. The posterior coelomic sac (*post. c.*) is represented by a band of cells extending backwards over the stomach. All the processes of the longitudinal ciliated band are well seen. Magnification 22 diameters.

Fig. 6.—Specimen of *A. antarctica*, slightly older than that shown in Fig. 2, viewed from the left dorso-lateral aspect. The posterior coelomic sac is in the act of dividing into right and left posterior coeloms (*r. p. c., l. p. c.*). Magnification 22 diameters.

Fig. 5.—One of the oldest specimens of *A. antarctica* viewed from the dorsal aspect. The hydrocoele (*hy.*) shows the beginnings of the primary lobes; it is sharply marked from the anterior coelom (*ant. c.*), with which it is connected only by a constricted canal. The posterior coelom is completely divided into right and left posterior coeloms, which are situated at the sides of the stomach. Magnification 22 diameters.

Fig. 4.—A portion of the specimen of *Auricularia nudibranchiata* viewed from the dorsal aspect, showing oesophagus, stomach, and adjacent coelomic cavities; *p. c.* the pore-canal running along the posterior aspect of the anterior coelom. Magnification 16 diameters.

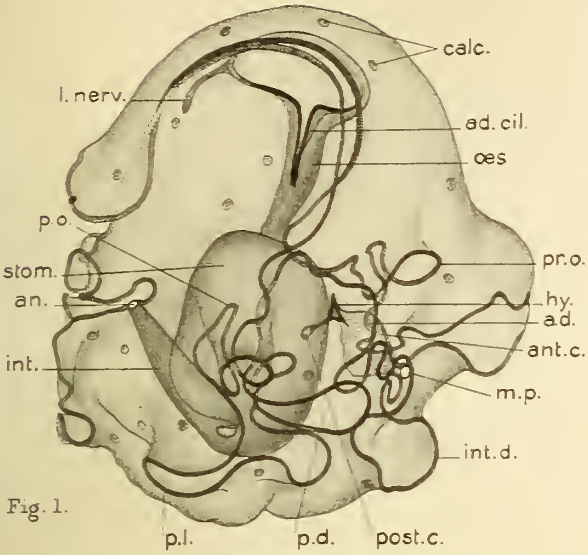


Fig. 1.

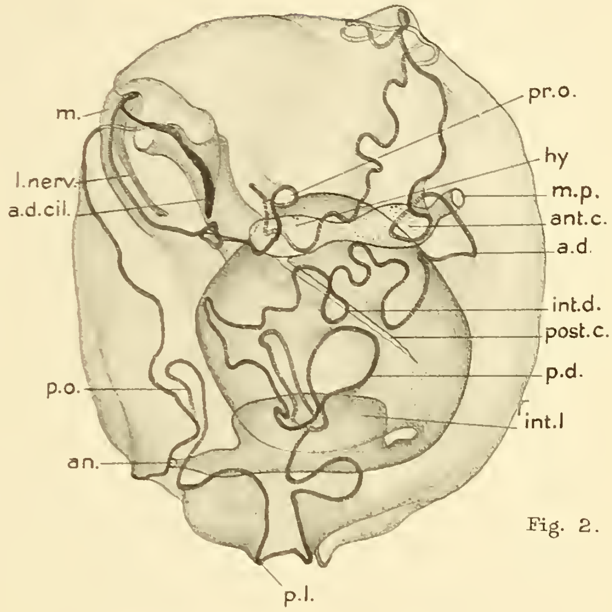
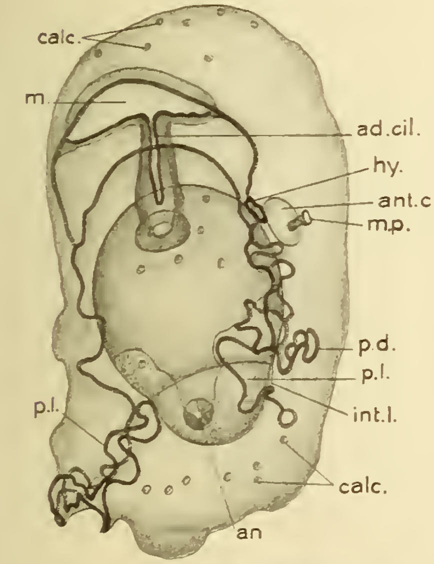


Fig. 2.



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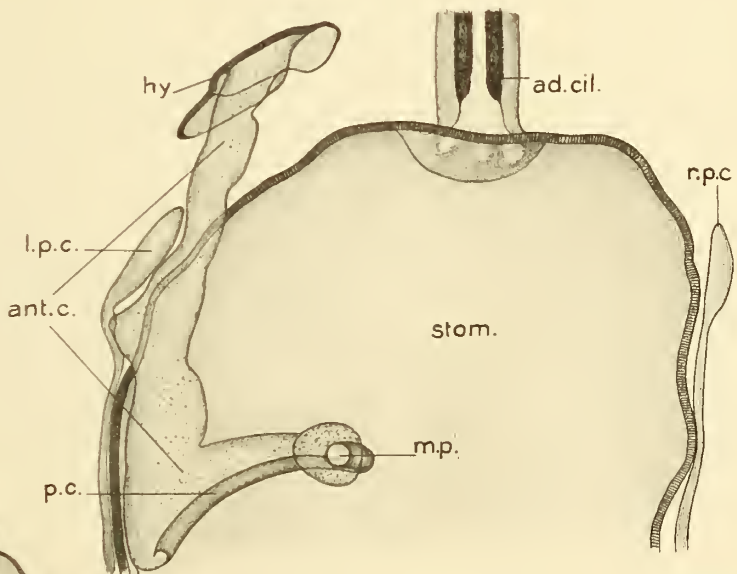
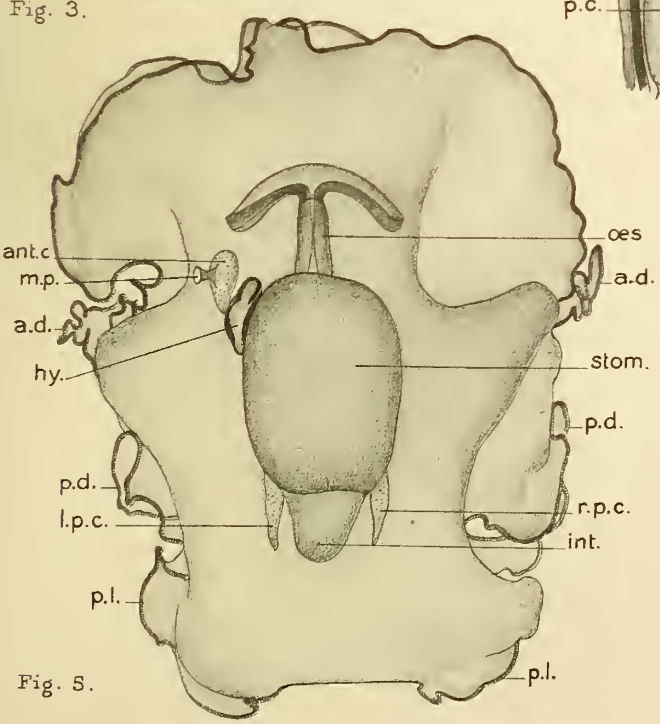


Fig. 4.



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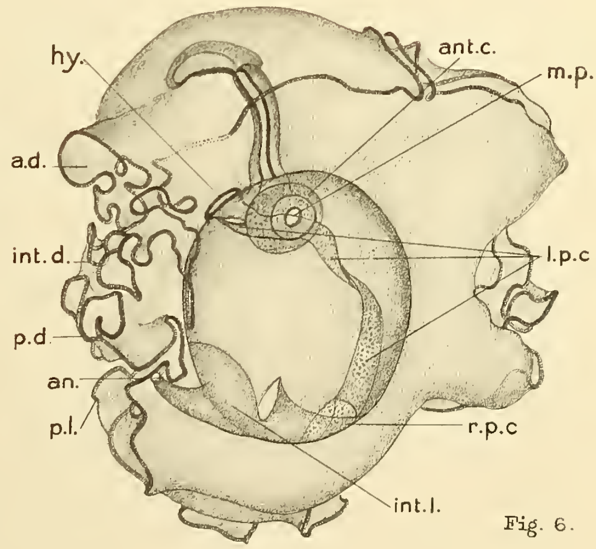

Fig. 6.

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PLATE II.

Bipinnaria antarctica	Figs. 7, 8.
Tornaria grenacheri	Figs. 9, 10.

List of Abbreviations employed.

ab. p. aboral plates of starfish.
a. d. antero-dorsal arm of *Bipinnaria*.
ad. cil. adoral ciliated band.
an. anus.
ant. c. anterior coelom of *Tornaria*; conjoined right and left anterior coeloms of *Bipinnaria*.
ap. apical plate of *Tornaria*.
cil. ep. ciliated epithelium.
cil. r. ciliated ring of *Tornaria*.
coll. collar-groove of *Tornaria*.
d. p. dorsal pore of *Tornaria*.
gl. ep. glandular epithelium of base of proboscis-cavity or anterior coelom of *Tornaria*.
H. heart of *Tornaria*.
h. gl. heart-gland.
hy. hydrocoele.
int. intestine.
l. a. c. left anterior coelom of *Bipinnaria*.
l. h. left horn of proboscis-cavity or anterior coelom of *Tornaria*.
long. musc. longitudinal muscle-fibrils.
l. p. c. left posterior coelom.
m. d. median dorsal arm of *Bipinnaria*.
m. v. median ventral arm of *Bipinnaria*.
nch. rudiment of notochord of *Tornaria*.
oc. eye-pit of *Tornaria*.
oes. oesophagus.
p. d. postero-dorsal arm of *Bipinnaria*.
per. pericardial sac of *Tornaria*.
p. l. postero-lateral arm of *Bipinnaria*.
p. o. post-oral arm of *Bipinnaria*.
pr. o. prae-oral arm of *Bipinnaria*.
r. a. c. right anterior coelom of *Bipinnaria*.
r. h. right horn of anterior coelom of *Tornaria*.
r. p. c. right posterior coelom.
stom. stomach.

Fig. 7.—A specimen of *Bipinnaria antarctica* viewed from the ventral aspect. The postero-lateral and post-oral arms of the right side (left side of the figure) are broken off, and their former positions are indicated by dotted lines; *ab. p.* organic bases of the aboral (terminal) plates of the future starfish, each carrying two conical spines; *ant. c.* union of right and left coelomic sacs in the prae-oral lobe; *long. musc.* longitudinal muscle-fibres of the arms.
Magnification 16 diameters.

Fig. 8.—A portion of one of the arms of another specimen of *B. antarctica* viewed from the side; *cil. ep.* ridge of ciliated epithelium bordering the groove. Magnification 140 diameters.

Fig. 10.—A specimen of *Tornaria grenacheri*, Spengel, in the act of metamorphosis, viewed from the dorsal and posterior aspects; *a. p.* apical plate, with *oc.* the eye-pits; *cil. ep.* remnants of longitudinal ciliated band; *cil. r.* posterior ciliated ring; *d. p.* dorsal pore; *gl. ep.* glandular epithelium—rudiment of proboscis-gland; *nch.* rudiment of notochord; *coll.* beginning of collar-groove.
Magnification 22 diameters.

Fig. 9.—The dorsal pore and adjacent organs of the specimen shown in Fig. 10 viewed from the ventral and anterior aspect; *H.* heart; *h. gl.* heart-gland; *per.* pericardial sac; *r. h.* and *l. h.* right and left horns of the anterior body-cavity. Magnification 60 diameters.

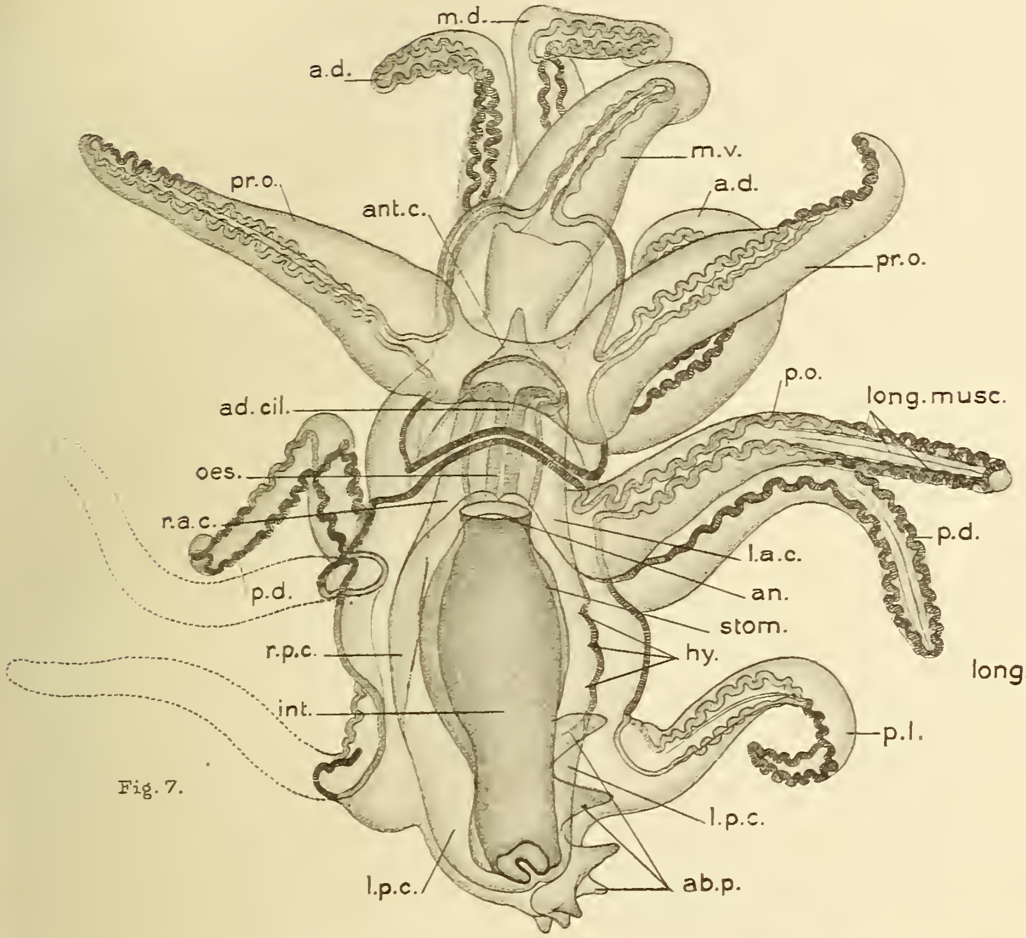

Fig. 7.

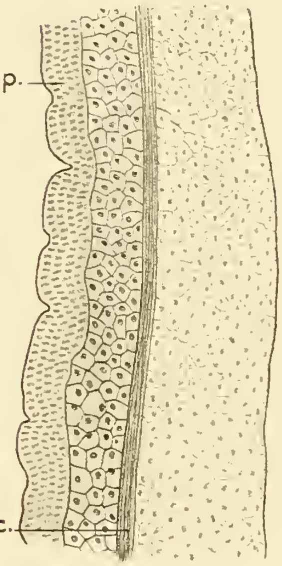

Fig. 8.

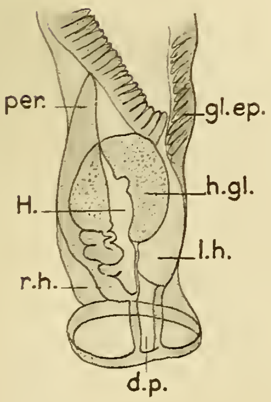

Fig. 9.

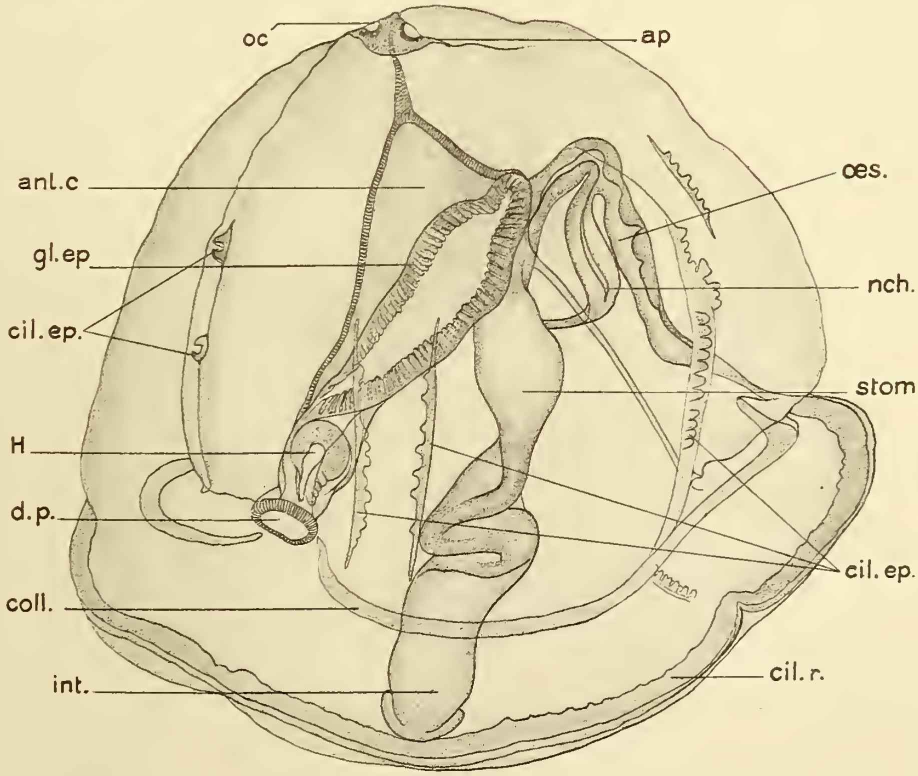

Fig. 10.

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RHABDOPLEURA.

BY

J. R. NORMAN.

WITH [illegible] FIGURES IN THE TEXT.

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RHABDOPLEURA.*

By J. R. NORMAN.

WITH SIX FIGURES IN THE TEXT.

I.—INTRODUCTION AND HISTORICAL REVIEW.

I HAVE to thank Sir Sidney Harmer, K.B.E., F.R.S., for entrusting me with this investigation, and Professor E. W. MacBride, F.R.S., for permitting me to carry out the work under his supervision in the Huxley Research Laboratory of the Imperial College of Science, and for the frequent and valuable advice that he has given me during its progress.

Rhabdopleura was dredged in 1868 by A. M. Norman and Jeffreys, and described by Allman (1, 2) in the following year as *Rhabdopleura normani*, a peculiar form of Polyzoa.

Rhabdopleura had been previously dredged by G. O. Sars (19, p. 23) in 1866, mentioned by M. Sars † in 1868 as *Halilophus mirabilis*, and fully described by G. O. Sars (18, 19) in 1872 and 1874 as *Rhabdopleura mirabilis*.

In 1874 Lankester (14) expressed the opinion that *Rhabdopleura* was related to the Lamellibranch Molluscs. In 1882 McIntosh ‡ published the preliminary notice of *Cephalodiscus*, in which he suggested that *Rhabdopleura* was probably closely related to that genus ; and when Harmer (8) showed in 1887 that *Cephalodiscus* was related to *Balanoglossus*, the systematic position became more clear. The thorough investigation

* Manuscript received April 28, 1921. [S.F.H.]

† "Fortsatte Bemaerkninger over det dyriske Livs Udbredning i Havets Dybder," Christiania Vid. Selsk. Forh., 1868–1869, p. 255.

‡ Ann. Mag. Nat. Hist. (5), X., 1882, pp. 337–348.

made by Lankester (15) in 1884, and the subsequent work of Fowler (5, 6, 7), with "Challenger" material, further strengthened the view that *Rhabdopleura* and *Cephalodiscus* were closely related.

The unillustrated publications of Conte and Vaney (3, 4) in 1902 contain results which stand in direct opposition to those obtained by all other workers.

The most recent work on *Rhabdopleura* has been carried out by Schepotieff (20–24), whose series of papers published from 1904 to 1909 contain detailed accounts of the morphology of the organism, together with important conclusions relating to the buds and method of budding, and to the affinities of the genus. These publications complete the proof of the fundamental resemblance between *Rhabdopleura* and *Cephalodiscus*. The relations between the two genera were summarised by Ridewood (17) in 1907.

Other investigators such as Hincks (11), Jullien (12, 13), and Norman (16), have published accounts of *Rhabdopleura*, but have only dealt with it from a systematic standpoint.

II.—SPECIES AND THEIR DISTRIBUTION.

In *Rhabdopleura*, as in *Cephalodiscus*, the characters of the cœnœcium (tubarium *) form the principal means of distinguishing the species. A number of species have been described, but it is not yet possible to say how far all of these are distinct. Schepotieff (22, p. 471) notes that the form of the cœnœcium tends to vary considerably even in a single colony, and suggests that probably all the specimens of *Rhabdopleura* known (in 1906) belong to the same species, i.e. *R. normani*.

The occurrence of *Rhabdopleura* among the "Terra Nova" dredgings is interesting in that it extends the geographical range of the genus, which appears to be almost world-wide. The extreme limits from which it has been recorded are West Greenland † and South Australia (Harmer 9, p. 23.) ‡

The following represents a synopsis of all the species of *Rhabdopleura* which have been described, together with the localities and depths from which material of these species has been obtained :—

1. *R. normani*, Allman (2) [? = *R. mirabilis*, Sars].—Characterised by the great length of the free, upright peristomes. Greenland ; Shetland Islands ; Norwegian coasts ; Tristan d'Acunha. Depth varies considerably ; 5 m. (22, p. 468) to 500 m.

2. *R. compacta*, Hincks (11).—Peristomes short ; tubes set closely side by side, forming small, crust-like colonies. Coasts of Ireland and Brittany. 100 m.

3. *R. grimaldii*, Jullien (12).—Peristomes short, each continuing a creeping portion of equal length ; two delicate "tubes" running longitudinally along the free

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* Lankester (15), p. 624.

† Norman, A.—" Notes on the Natural History of East Finmark." Ann. Mag. Nat. Hist. (7), XII, 1903, p. 101.

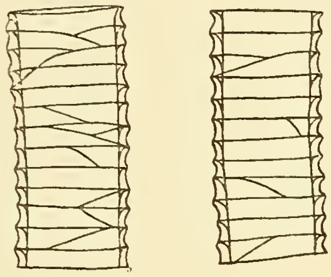
‡ This was merely a fragment, and could not be referred to any particular species.

wall of the creeping portion, converging anteriorly, and ending at the base of the peristome; pectocaulus not extending into the recumbent portion of the zoœcium; cœnœcium brown. Azores. 318 m.

4. *R. manubialis*, Jullien (13).—Peristome twice as long as the attached portion; longitudinal "tubes" of *R. grimaldii* absent; pectocaulus extending into the recumbent portion of the zoœcium; cœnœcium yellow. Azores. 318 m.

5. *R. striata*, Schepotieff (24).—Peristome composed of plates arranged in regular circles; pectocaulus paler than in *R. normani*, and hollow, so that the body-cavities of separate individuals communicate with one another. Indian Ocean (Coast of Ceylon). 2 to 3 m.

6. *R. annulata*, n.sp. Three Kings Islands, north of New Zealand; islands of Wowoni and Buton (near Celebes). 183 to 549 m.

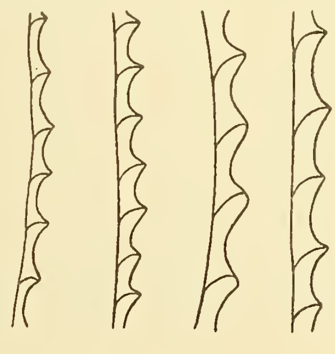


A B

Fig. 1.—*Rhabdopleura normani*. Portions of peristomes (×56). A, Specimen from Norway (Harmer 10). B, Specimen from Tristan d'Acunha.

On the suggestion of Sir Sidney Harmer, a re-examination of the *Rhabdopleura* material, dredged on the "Challenger" Expedition, was undertaken with a view to ascertaining whether the "Challenger" material from Tristan d'Acunha described by Fowler (5, 6, 7) is identical with *R. normani*. Through the courtesy of Mr. R. Kirkpatrick, of the British Museum (Natural History), I have examined authentic material of *R. normani* from Norway and the Shetlands, collected by A. M. Norman. I have also had the advantage of studying preparations made by Sir Sidney Harmer, from material from Norway, and now in the Cambridge Museum.

The specimens from Norway in the British Museum, and those from Tristan d'Acunha, are all attached to colonies of *Lophohelia prolifera*, and Fowler (5, p. 293) remarks, concerning the material from the latter locality, that "it is not a little remarkable that the two species thus associated should be apparently identical with the species of these genera which are associated off Norway and the Shetlands, though separated by about 98° of Latitude."



A B C D

Fig. 2.—*Rhabdopleura normani*. Optical sections of peristomial tube-walls (× 185). A–C, Specimens from Norway (Norman Collection). D, Specimen from Tristan d'Acunha.

The peristomes of the specimens from Tristan d'Acunha (Fig. 1, B) very closely resemble those prepared by Harmer from specimens from Norway (Fig. 1, A), one of which was figured by him in the Siboga Report (10, Pl. 11, Fig. 19). The remaining parts of the cœnœcium also appear to be similar. The peristomes, however, differ from those of the colonies collected by Norman, which appear to vary considerably, both in different colonies, and even in the same colony. This variation affects the diameter of the peristomes, the thickness

of the peristomial walls, and the character and extent of the lateral projections of the peristomial walls (Fig. 2).

It would appear, therefore, that if the characters of the cœnœcium may be taken as a reliable means of distinguishing the species, as Harmer (10, p. 127) thought probable, the colonies of *Rhabdopleura* from Tristan d'Acunha are referable to *R. normani.*

The following table of measurements of the diameters of the peristomes, and thickness of the peristomial walls, is compiled from measurements made by Harmer (10, p. 127), and Schepotieff (20, p. 6), and from measurements made by me from "Norman" material in the British Museum (Natural History), and from "Challenger" material.

	Harmer.	Schepotieff.	Norman Coll. Brit. Mus. (Nat. Hist.)	"Challenger" Material.
Internal diameter of peristomial tube	255–270μ	180–185μ	130–200μ	180–260μ
Thickness of wall at the middle of a tube-ring	16–24μ	under 8μ	3–10μ	2–18μ

III.—MATERIAL COLLECTED BY THE "TERRA NOVA."

The material of *Rhabdopleura* collected by the "Terra Nova" Expedition was obtained at two stations lying to the north of New Zealand. Station 90—July 25th, 1911 ; from Summit, Great King, Three Kings Islands, New Zealand, S. 14° W., 8 miles, 100 fathoms (183 m.), rock. Station 91—July 26th, 1911 ; from Summit, Great King, Three Kings Islands, New Zealand, S. 10° W., 25 miles, 300 fathoms (549 m.), rock.

The material consists of two small stones and one Lamellibranch shell dredged from 100 fathoms, with the *Rhabdopleura* colonies in a broken condition ; and one larger stone dredged from 300 fathoms, with an extensive colony in better condition.

All the material was preserved in 70 per cent. alcohol. The state of preservation was very poor, and the zooids were found to be much decomposed, rendering an examination of any structural details impossible. A description of the cœnœcium, therefore, was all that could be undertaken.

The specimens cannot be referred to any existing species, and the name *Rhabdopleura annulata* is proposed, on account of the projections of the peristomial tube-rings.

RHABDOPLEURA ANNULATA, N.SP.

Colony irregularly branched and attached to stones or shells. Cœnœcium of a pale brown colour. Diameter of the free, cylindrical portions the same as that of the adherent portions. External projections of the peristomial rings very clearly marked. The free peristomes arise directly from the creeping part of the cœnœcium, which contains the pectocaulus, and are not recumbent for any part of their length. Length

of the peristomes and the number of peristomial rings varying considerably. Internal diameter of peristomes, 160–200μ. Maximum external diameter (i.e. across the angular projections of the tube rings), 265μ. Maximum thickness of peristomial wall, 30–60μ. Minimum thickness of peristomial wall, 9–13μ. Average distance between tube-rings, 50μ. Pectocaulus of a deep black colour, 27–34μ in diameter.

Where the cœnœcium is attached to a stone, the tubes are found on almost every side of the stone, although the greater part of the colony is confined to one surface. The colony attached to the shell is largely confined to the outer surface of the valve, although small portions of the cœnœcium are to be seen on the concave surface.

In all the colonies, the tubes, especially the free upright peristomes, have been considerably damaged, which damage is probably due largely to the shaking in the bottles which the specimens must have undergone before being handed over for investigation. For this reason it was impossible to follow the course of the colony for any distance, or to investigate the manner of branching, and the starting point of the colony.

Many Hydroids and Polyzoa are associated with the *Rhabdopleura* colonies, which, in their older parts, are actually encrusted with foreign growths.

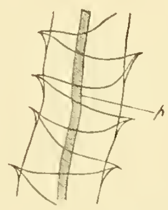


Fig. 3.—*Rhabdopleura annulata*, n.sp. A fragment of the creeping portion of the cœnœcium viewed from above (× 56); *p.*, pectocaulus.

The cœnœcium is transparent, and coloured pale brown, but in some parts it appears dark brown or even black, owing to the decomposition of the contained zooids and buds.

The creeping stem (Fig. 3), attached to the stone or shell, shows the oblique sutures which have been noticed in other species, and impart to it a zig-zag appearance. It contains the characteristic pectocaulus (*p.*, Figs. 3, 4) embedded in its lower wall. The tube-wall of this part of the cœnœcium is marked by lateral projections, which are not quite so prominent as those of the peristomial wall. In fragments of the creeping stem it may be observed that the pectocaulus does not always lie in the middle line of the basal wall, but may be found at the extreme edge. This is probably due to its detachment during the preparation of the slide. The average diameter of the pectocaulus is about 31μ, but measurements taken at various parts give diameters ranging from 27 to 34μ. The inner surface of the attached portion of the cœnœcium, as well as of the free, upright peristomes, is perfectly smooth.

The creeping stem is divided internally into a number of compartments by transverse septa (*sp.*, Figs. 4, 5), and from each of these compartments the perpendicular, free branches or peristomes are given off. These branches, which contain the zooids during life, differ from the branches described in *R. normani*, in that they are never recumbent for any part of their length, but arise directly at right angles from the creeping stem containing the pectocaulus (see Fig. 4). A similar arrangement was noted by G. O. Sars (19) in his description of specimens obtained from the Lofoten

Islands, and it was this feature which led him to separate his specimens from those described by Allman, under the name of *R. mirabilis*.

Lankester (15, p. 626) notices that Sars obtained his specimens " in fragments growing upon coarse sand—attached not to a continuous support, but to one piece after another of coarse angular rock particles." He suggests that the difference between the specimens of Sars and Allman is one which is merely due to the nature of the surface on which the colony is growing ; and considers that Sars has not given sufficient reason for separating *R. mirabilis* from *R. normani*. Schepotieff (22, p. 470) is of the same opinion, and further notes that where a *Rhabdopleura* colony is growing on smooth surfaces such as mussel-shells or flat stones, the peristomes tend to rise directly vertically from the creeping portion containing the pectocaulus ; whereas, where the surface is broken and irregular, such as tubes of *Serpula* and pieces of coral, the lateral branches containing the zooids tend to be recumbent for a part of their length.

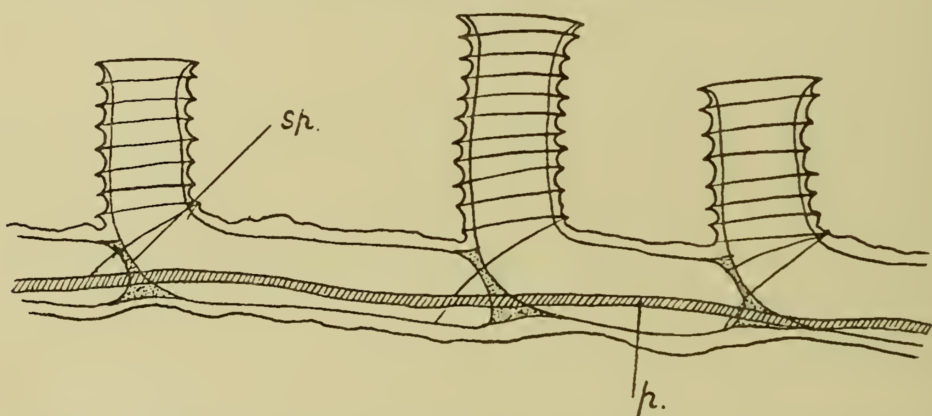


Fig. 4.—*Rhabdopleura annulata*, n.sp. A fragment of the creeping portion of the cœnœcium viewed from the side, with three peristomes (× about 56). Slightly diagrammatic ; *p.*, pectocaulus ; *sp.*, septum.

This statement does not appear to be true in all cases, for all the colonies dredged by the " Terra Nova " Expedition are growing on surfaces which are partly smooth and partly broken. In all cases, however, the colonies exhibit the arrangement noticed by Sars, that is, the peristomes arise directly at right angles from the creeping stem. Further, the colonies of *R. normani* in the British Museum, and those dredged by the " Challenger " Expedition, are growing either on pieces of coral, or on a perfectly smooth shell, but the lateral branches are here recumbent for a part of their length. It would seem, therefore, that in *R. annulata* at any rate, this is a truly specific feature, and in no way due to the nature of the surface to which the colony is attached.

The distance between the points where the peristomes are given off varies considerably, two peristomes sometimes ascending side by side, and sometimes separated by a distance of 3 to 8 mm. The peristomes are, as a rule, more or less straight, but twisted specimens are occasionally found.

The height of the free peristomes varies greatly, as does the number of rings on each peristome. I have examined an extensive series of complete peristomes, and find

that the number of tube-rings varies from 9 to 47. The number of rings is undoubtedly correlated with the age of the contained zooid, which adds rings at intervals to the free edge of the peristome.

The average distance between the sharply projecting peristomial rings is 50μ. These rings are more prominent than in *R. normani*, giving the peristome a more clearly annulated appearance. As has been noticed in other species, the rings are not complete, but are interrupted by oblique sutures (*s.*, Fig. 5). They are clearly described and figured by Schepotieff (20, p. 6, Pl. I, Fig. 3) in *R. normani*. Harmer (10, p. 8) notes that "the suture is easily seen when it is on that side of the ring which faces the observer, less easily when it is necessary to focus through the tube in order to see it, and may be difficult to distinguish when it is on either side of the tube." From examination of a number of peristomes it would seem that the suture is an ordinary feature of the peristomial ring, and represents the junction between the part first formed by the zooid, and that last formed.

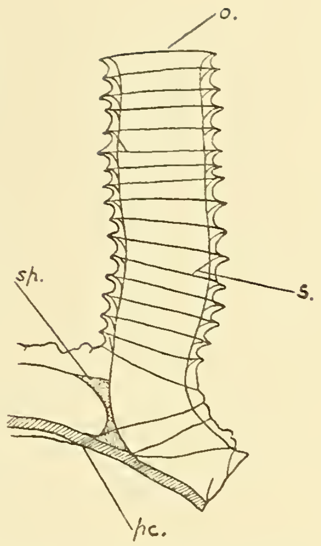


Fig. 5.—*Rhabdopleura annulata*, n.sp. A complete peristome (× 56); *o.*, orifice of tube; *pc.*, pectocaulus; *s.*, suture of tube-ring; *sp.*, septum.

The projections of the peristomial rings are very clearly marked, and form one of the main features which distinguish the species. They stand out as much as from 30–50μ from the tube-wall, as compared with 15μ in *R. normani* (Schepotieff, 20, p. 6). The extent of these angular projections in *R. annulata* is shown in Fig. 6.

In describing a specimen of *Rhabdopleura* obtained from near Celebes (Stn. 204) by the "Siboga" Expedition, Harmer (10, p. 127) noticed the angular projections of the tube-rings. He suggests that the "Siboga" specimen is probably a new species characterised by the small number of tube-rings, by their comparative delicacy and thinness, and by their angular projections to the exterior. The specimen was so fragmentary, however, that he did not consider himself justified in giving it a specific name, but it seems probable that it belongs to the species here described as *R. annulata*. The measurements of the two are as follows :—

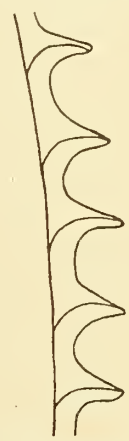


Fig 6.—*Rhabdopleura annulata*, n.sp. Optical section of a peristomial tube-wall (× 185).

	Specimens from "Siboga," Station 204.	Specimens from "Terra Nova," Stations 90, 91 (*R. annulata*, n.sp.).
Internal diameter of peristomial tube	175–210μ	160–200μ
Thickness of wall at the middle of a tube-ring	7·5–11·5μ	9–13μ

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NATURAL HISTORY REPORT.

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BIRDS.

BY

P. R. LOWE, O.B.E., B.A., M.B. (CANTAB.), AND N. B. KINNEAR

(Assistant-Keepers in the Zoological Department).

WITH TWENTY-FOUR TEXT-FIGURES AND SIXTEEN PLATES.

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I. INTRODUCTORY NOTE.

DURING the voyage of the "Terra Nova" observations on birds were made and recorded by several members of the Expedition, but chiefly by Dr. E. A. Wilson. Had he survived he would no doubt have produced a report as valuable as that which he had previously written on the birds of the first "Discovery" expedition. On the return of the "Terra Nova" Dr. Wilson's notes, together with the specimens collected on the voyage, were placed in the hands of the late Mr. W. R. Ogilvie-Grant, and under his direction the plates now published were reproduced from sketches by Dr. Wilson. Once again, however, death intervened, and it is only now, after many years, that Mr. P. R. Lowe and Mr. N. B. Kinnear have been able to bring together the material left by their predecessors and to add to it the results of their own studies. The delay has, however, made it possible to institute careful comparisons of the rich collections of Antarctic and Sub-antarctic Birds now in the Museum with those in other Museums, especially those of Edinburgh, Tring, and Paris. The results of these comparisons, set out at length in the tables here given, have enabled important conclusions to be reached regarding some supposed sub-species and their geographical distribution.

W. T. CALMAN, *Keeper of Zoology.*

List of Species and Sub-species obtained or recorded

1. *Aptenodytes forsteri.*
2. *Pygoscelis adeliae.*
3. *Sterna* sp.
4. *Gygis alba alba.*
5. *Catharacta skua intercedens.*
6. *Catharacta skua lonnbergi.*
7. *Catharacta skua maccormicki.*
8. *Oceanodroma castro.*
9. *Oceanites oceanicus.*
10. *Fregetta tropica melanogaster.*
11. *Fregetta tropica tropica.*
12. *Bulweria bulwerii.*
13. *Puffinus tenuirostris brevicaudus.*
14. *Calonectris kuhli edwardsii.*
15. *Adamastor cinerea.*
16. *Thalassoeca antarctica.*
17. *Priocella antarctica.*
18. *Procellaria aequinoctialis.*
19. *Pterodroma lessoni.*
20. *Pterodroma arminjoniana.*
21. *Pterodroma mollis mollis.*
22. *Pterodroma macroptera macroptera.*
23. *Pagodroma nivca nivea.*
24. *Macronectes giganteus.*
25. *Daption capensis.*
26. *Halobaena caerulea.*
27. *Prion sp.*
28. *Pelecanoides urinatrix exsul.*
29. *Heteroprion desolatus alexanderi.*
30. *Diomedca exulans.*
31. *Diomedea epomophora.*
32. *Thalassarche melanophris.*
33. *Thalassarche chrysostoma.*
34. *Thalassarche chlororhynchos.*
35. *Phoebetria palpebrata.*
36. *Phoebetria fusca.*
37. *Sula sula.*
38. *Sula leucogaster.*
39. *Fregata wilsoni.*
40. *Fregata minor nicolli.*

1. *Aptenodytes forsteri* (Emperor Penguin). Text-figs. 1 and 2.*

Aptenodytes forsteri Gray, Ann. Mag. Nat. Hist. xiii, p. 315, 1844 (77° S., 180° E.); Ogilvie Grant, Cat. Birds Brit. Mus. xxvi, p. 626, 1898; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 1, 1907.

MATERIAL OBTAINED

No. 62.	♀ 2.iv.1911.	Cape Evans.
No. 64.	♀ 31.i.1912.	Found on berg off Cape Evans. Moulting.
No. 66.	♀ 11.ii.1912.	Cape Evans.
No. 70.		Cape Royds.

Four unlabelled specimens from "Terra Nova" Expedition, 1911.

* It should be mentioned that many of the text-figures have been reproduced from rough sketches in Dr. Wilson's diary. In some cases it has been difficult to determine the species actually represented. Probably there was doubt in Wilson's own mind, as any one will understand who has attempted to identify birds at sea.

Dr. Wilson wrote very fully on the Emperor Penguin in his report on the "Discovery" Expedition, and the few extracts from his Zoological diary given below are all notes he recorded during the present expedition.

Dec. 9, 1910.—65° 8′ S., 177° 41′ W. A solitary one in its first or second year on an ice-floe at 3 p.m.

Dec. 19, 1910.—About 67° 50′ S., 178° W. One young and one old bird.

Dec. 29, 1910.—Two young birds seen. One had the throat blackish-grey and the neck whitish; the other was younger, throat white and neck-patch grey. Both lopped into the water at once off a floe. I also saw one adult alone.

Dec. 31, 1910.—72° 54′ S., 174° 55′ E. Open water and hove to under the lea of the pack ice in a southerly gale. One old one alone and four young ones in the pack ice, also one other young one all fairly full-grown.

Jan. 3, 1911.—Numbers increasing.

Jan. 4, 1911.—Five miles E. of Cape Crozier. Came up to Ross Barrier about five miles east of Cape Crozier and then proceeded west. We did not see one

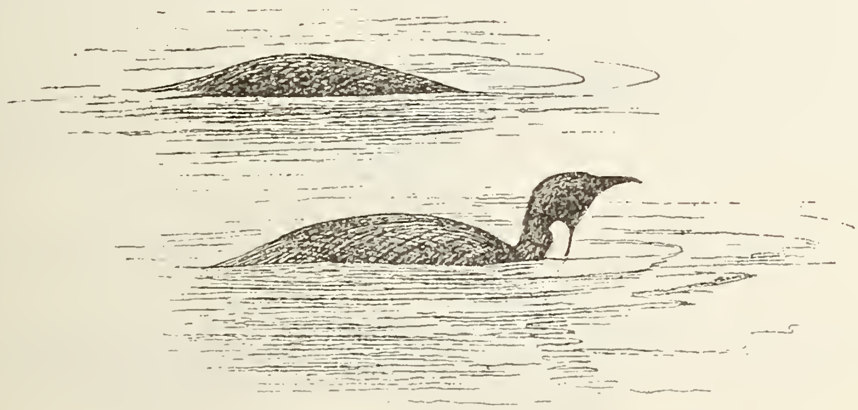

Fig. 1.—Emperor Penguin (*Aptenodytes forsteri*). Adults, feeding and swimming in the water.

alive, either adult or young, until we attempted to make a landing at this junction of rock-cliff and barrier, when we found a half-grown young one in partial down standing on a pressed-up dirty piece of sea-ice, about 6 feet above water and near it an adult Emperor asleep. [Text-fig. 2.] The chick was larger than any I have seen in the down, and had already begun to shed the down on the head, fore-breast and back (?) and the wings were quite free from down. The adult looked very sick of life. The chick walked away from the edge of the ice. We might have knocked off and so have obtained it, had there not been so much swell that any attempt to land or even approach the edge of the ice was impossible. The ice on which these two birds stood was raised well above the sea and was bent upwards so as to form a sort of cave in which the swell rose and fell. The ice was very dirty sea-ice, a mere remnant of the old winter's bay-ice, and hanging beneath it were the remnants of several dead Emperor Penguin chicks as well as an old one. The toes of these dipped every now and again in the swell. Here and there dead Emperor chicks were floating in the open water, evidently washed out of old bay-ice. [See Text-fig. 2.]

This was the only visible sign of the Emperor Penguins, but it established a new fact in the life-history and falls in with what we had believed, namely that the chick is very slow in shedding its first plumage and the egg has to be laid and hatched out during the winter months.

After landing Captain Scott and his party, Commander Pennell returned to New Zealand in the "Terra Nova," and during this and subsequent voyages he and other members of the ship's company made careful notes in the zoological log of all the birds seen.

On January 31, 1911, in 78° 29′ S., 170° 56′ W., there is an entry, "counted about twenty at the head of Discovery Bay with Adelies, which were seen in the water but not the Emperors. On shore they were intermingled. Penguin-tracks were numerous."

FIG. 2.—Emperor Penguin (*Aptenodytes forsteri*). Adult with half-grown chick.

When near Cape Colbeck in 76° 56′ S., 159° 01′ W., on February 2, many were seen but no more were observed after the 26th of the month, when—"Four were seen on the floe" off the N. coast of Victoria land in 68° 57′ S., 158° 53′ E.

During the second voyage south in the following year, the first Emperors were met with on January 1, 68° 44′ S., 178° 55′ E., three being seen "with no yellow on the throat." On the 6th in 74° S., 171° 18′ E., another immature bird was noted and from that date onwards odd birds were recorded daily till 76° 03′ S., 165° 55′ E., on January 10, when an adult female was captured. On February 23, 75° 43′ S., 164° 20′ E., the following entry appears in the log: "Stopped in heavy pancake ice off Drygalski Barrier Tongue. Twelve Emperor Penguins in a group standing on the ice right alongside. All had yellow necks and were very large birds. Seen in the water later

they came right up under the counter, making a very distinct blow like a seal, but not quite so loud. They kept their beaks open all the time their heads were out of the water, which on this occasion was never more than five to ten seconds, although their bodies were sometimes on the surface much longer. Altogether, in the afternoon and evening, well over a hundred Emperors were seen. All close enough to see well were adult birds with yellow necks. Their plumage looked quite good."

The last examples of this penguin were noted in 75° 20′ S., 166° 30′ E., when two were seen on March 6.

On the final voyage south no Emperors were met with till 70° 39′ S., 166° 17′ W., was reached on December 30, 1912, when three were seen early in the morning. Next day three adults were observed close to the ship, three more were seen on the following day, and on January 5 in 71° 48′ S., 166° 48′ W., an adult was noted " yellow neck, moulting. In a very unhappy state." Three days later (71° 41′ S., 167° 04′ W.) the entry runs : " Three Emperor Penguins together on a small berg. One, the largest, in middle of moult, the other two clean looking. All with yellow on neck." Apparently all adults. On the 13th, " One with yellow on neck, one young without sign of yellow," an adult and immature bird, were noted, and next day in 72° 45′ S., 172° 51′ W., another immature example is recorded. There are no further entries in the log after January 15, when the " Terra Nova " was in 73° 48′ S., 177° 15′ W.

2. *Pygoscelis adeliae* (Adelie Penguin). Plate XVI and Text-figs. 3–6.

Catarrhactes adeliae Hombron and Jacquinot, Ann. Sci. Nat. (2), xvi, p. 320, 1841 (Adélie Land) ; *Pygoscelis adeliae* Ogilvie-Grant, Cat. Birds Brit. Mus. xxvi, p. 632, 1898 ; Wilson, Nat. Ant. Exped. " Discovery," N. H. ii, Aves, p. 36, 1907.

Material obtained

No. 49.	♂	15.xii.1910.	67° 23′ S., 177° 58′ W.
No. 50.	♀	13.xii.1910.	67° 28′ S., 177° 58′ W.
No. 51.		15.xii.1910.	67° 23′ S., 177° 58′ W.
No. 54.		22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 55.		22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 56.		22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 57.	♂	22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 58.	♂	22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 59.	♂	22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 60.	♀	22.xii.1910.	68° 41′ S., 179° 28′ W.
No. 67.	♀	11. ii.1912.	Cape Evans.
No. 88.	♂	4.xii.1912.	Cape Royds.

No. 90. ♂ 4.xii.1912. Cape Royds.
No. 95. ♀ 5.xii.1912. ,, ,,
No. 96. ♂ 5.xii.1912. ,, ,,
No. 101. ♀ 6.xii.1912. ,, ,,
No. 102. ♂ 7.xii.1912. ,, ,,
No. 103. ♂ 7.xii.1912. ,, ,,
No. 117. ♀ 10.xii.1912. ,, ,,
No. 119. ♂ 10.xii.1912. ,, ,,
No. 125. ♂ 11.xii.1912. ,, ,,
No. 133. ♂ 13.xii.1912. ,, ,,
No. 134. ♀ 13.xii.1912. ,, ,,
I. ? Cape Adare.
K. ? ,, ,,
♂ 23.xii.1911. ,, ,,
♂ 4.xi.1911. ,, ,,
♀ 14.xi.1911. ,, ,,
A. juv. 21.xii.1911. ,, ,,
B. juv. 20.xii.1911. Cape Adare.
C. ,, ? ,, ,,
D. ,, ? ,, ,,

Dr. Wilson, in his report on the "Discovery" Collections, gave such a delightful account of this Penguin that we think it advisable to give *in extenso* the extract from his diary relating to this bird :—

Dec. 9, 1910.—65° 8′ S., 177° 41′ W. Two squatting on an ice-floe about 11 a.m., they looked like black-throated adults.

Dec. 10, 1910.—66° 38′ S., 17° 47′ W. One or two appeared in the pack. One was an immature white-throated bird, the other adult and black-throated.

Dec. 11, 1910.—About 67° S., 179′ W. A few adults, perhaps four or five in the day, and one or two young ones, with white chins and throats.

Dec. 12, 1910.—About 67° 15′ S., 178° W. One or two old black-throated, and one or two young white-throated.

Dec. 13–18, 1910.—67° 30′ S., 177° 58′ W. About six, one only was a young bird in immature plumage. It was killed with a rifle and had a grey throat. It was in company with two adult black-throated birds. One or two appeared from time to time. Adults seen to-day. I killed two young Adelie Penguins with the chin black and the throat white, also *the eyelids pure white* at this age. The feet were very pale indeed, almost white, very faintly pink, with brownish-yellow knuckles. The bill was not very brown. Under sail, moving slowly through the ice. Five immature birds together. Five birds both adult and immature.

Dec. 20–22, 1910. 68° 41′ S., 179° 28′ W. Small companies of young white-throated birds, often with one or two black-throated birds. Twenty-three young white-throated birds, of which we got eight. Also shot two young out

of three seen before. Two old black-throated birds were got by Nelson in the night. In small companies of half-a-dozen young white-throated birds here and there.

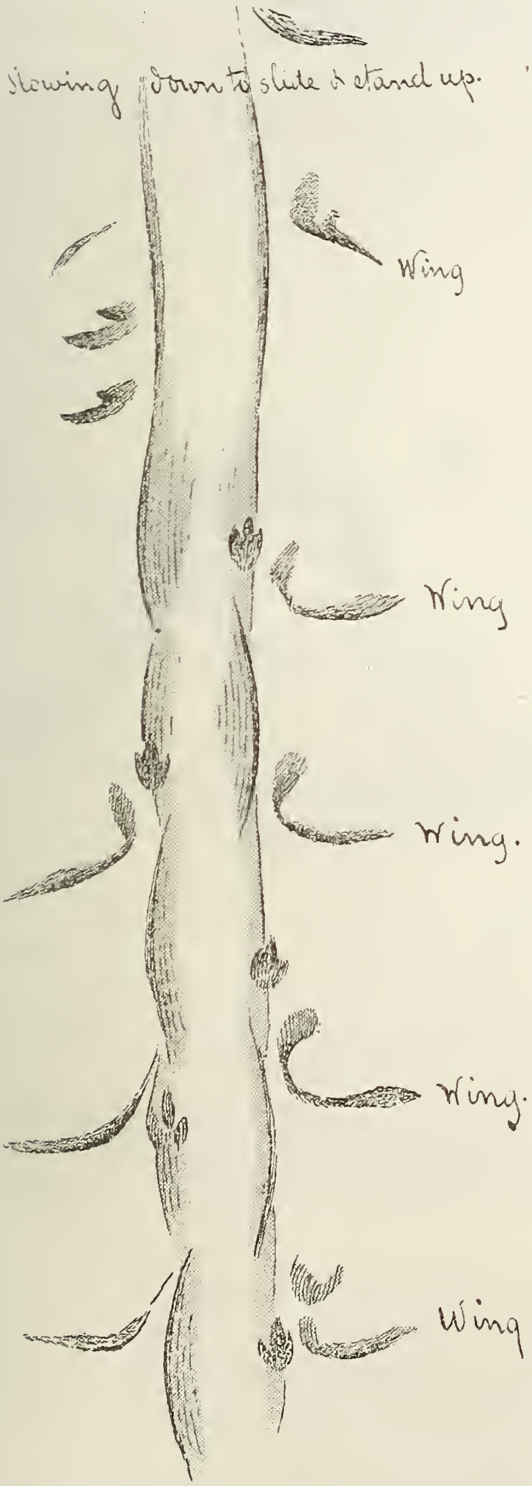

FIG. 3.—Adelie Penguin (*Pygoscelis adeliae*). Track of Adelie Penguin—going fast on its belly.

Dec. 25, 1910.—69° 5′ S., 178° 3′ W. Twenty-two young in one batch, all with white throats, also one or two adults with black throats.

Dec. 26, 1910.—69° 9′ S., 178° 13′ E. In small companies, chiefly young white-throated, about twenty or thirty per day for the last week.

FIG. 4.—Adelie Penguin (*Pygoscelis adeliae*). Track of Adelie Penguin—walking.

Dec. 27–29, 1910.—69° 12′ S., 178° 18′ E. Three or four at a time, chiefly young with white throats, porpoising and feeding in the open leads. Any number of young white-throated Adelie Penguins fishing in the water. I timed a small bevy of Adelies in the water and found that they remained fishing under a floe in deep water out of sight long enough for one to count 70 to 80 (30″ to 45″) each time. The Adelie swims almost entirely with its wings and in clear water constantly goes deep out of sight from the Crow's nest. The bird's body looks brown and the feet are extended with the black soles turned upwards. One sees the white edges of the thighs fringing the brown body very distinctly and the bird looks very like a small dolphin. A few young white-throated birds seen here and there. [See Text-fig. 6.]

Dec. 31, 1910.—72° 54′ S., 174° 55′ E. Open water and hove to under the lee of the pack in a southerly gale. A few small groups and some porpoising in the water.

Jan. 4, 1911.—Five miles E. of Cape Crozier. Very abundant indeed and the

rookery perfectly astounding as regards numbers. Through glasses many seemed to have young fluffy black chicks. None were to be seen of larger size in groups. There is a large offshoot rookery, west of the main one, quite separate.

Jan. 5, 1911.—McMurdo Sound. Passed a large rookery on Cape Bird, also a small one at Cape Royds.

Jan. 6–11, 1911.—Off Cape Evans. Great numbers, all adults, and full of fight with both men and dogs. At Cape Evans there were great heaps of Adelie Penguin feathers near the drift edge, evidently the refuse of moulting birds. On January 10 I saw three birds come up from the water

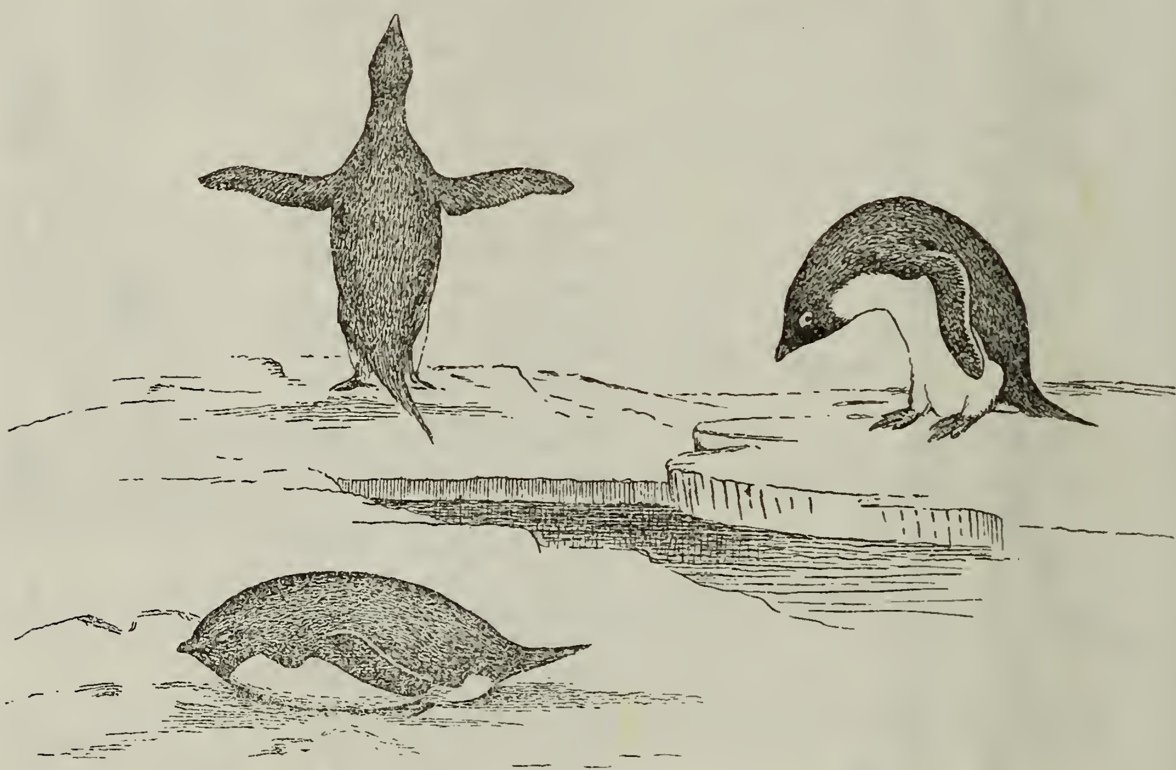

Fig. 5.—Adelie Penguin (*Pygoscelis adeliae*). Various poses.

into the middle of our camp, looking fat, large, and rather shabby about the feathers of the back. They appeared to me to be about to moult and had come to our sheltered bay. The pluck and impudence of the Adelies was quite astonishing.

On the return voyage of the "Terra Nova" from Cape Evans after landing the expedition, a very large rookery was observed on a steeply sloping hill, five miles south of Cape Bird, facing west, on January 28, 1911, and on numerous occasions this penguin was met with until March 12, in latitude 60° 46′ S., 161° 41′ E., when a single bird was seen in the water.

During the second voyage south of the "Terra Nova" in 1911–12 the first Adelie Penguin was met with on Dec. 28, when two were seen in 66° 20′ S., 177° 11′ W.

The following observation was made by Commander Pennell on January 22, in 77° 26′ S., 65° 17′ E.: "Adelie Penguins do not seem to mind the Killer Whale unless very close, for though at times they will come shooting out of the water on to a floe in evident hurry and a killer appears soon afterwards, yet at other times they will remain in the water quite close to a whale. It seems as if the killers tried to get them under the ice, and not attack them in the open water."

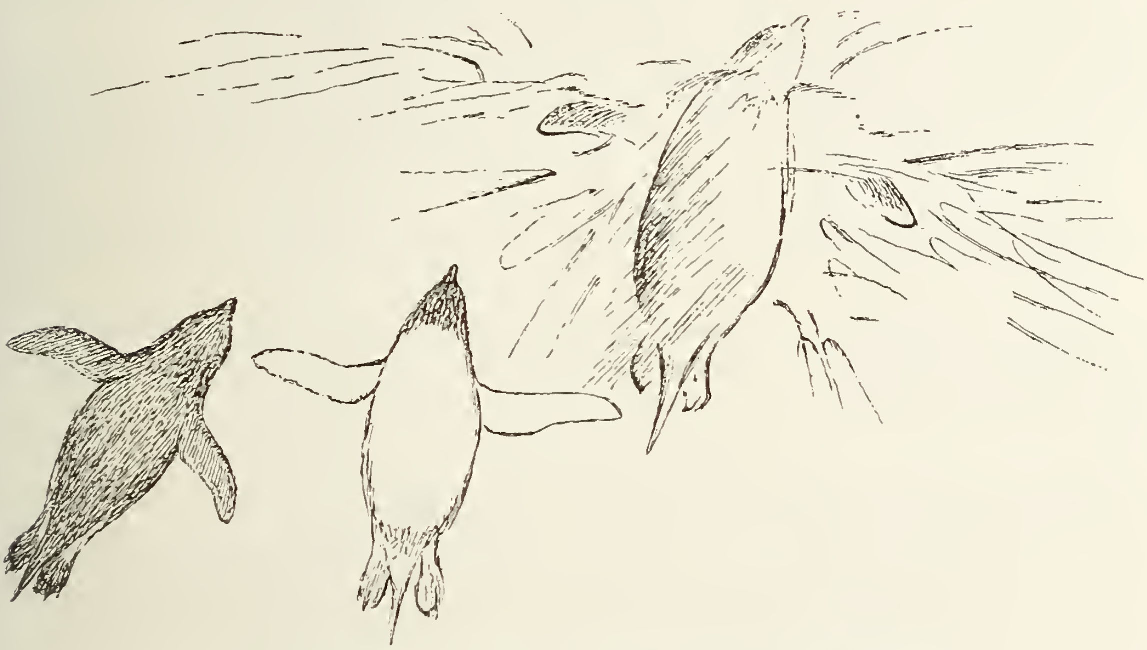

FIG. 6.—Adelie Penguin (*Pygoscelis adeliae*). Coming to the surface.

Three were seen in 63° 55′ S., 158° 31′ E., on March 19, the last seen on this voyage.

In the final voyage to Cape Evans the first birds were met with two days later in December than in the previous year and four degrees further south, viz. 70° 39′ S., 166° 17′ W. This was in pack-ice, but strangely enough none were seen after January 24, 70° 04′ S., 167° 26′ E., when the entry in the log runs: "Only three seen. There was also a remarkable absence of seals."

3. *Sterna* sp. (Tern).

Sterna sp. Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 63, 1907.

Dr. Wilson recorded seeing terns during the voyage of the "Discovery" in 67° 30′ S., 170° E., but though he was unable to secure any examples, he was inclined to think these birds were a form of *S. hirundinacea* rather than *S. vittata*.

Commander Pennell, while returning in the "Terra Nova" from Cape Evans in 1911, also observed terns on three separate occasions, but again it was not possible to

secure specimens and the identity of the species must still remain in doubt. His notes are as follows :—

March 4, 1911.—69° 11′ S., 160° 47′ E. (S.W. of Battery Island). Amongst heavy pack-ice : Two terns were seen at 8 p.m. with black heads, white rump and tail, and darkish-grey wings and back.

March 5, 1911.—67° 37′ S., 161° 42′ E. (W. of Battery Islands). At 8 p.m. three terns were flying round the ship calling rather like a sandpiper, but with a sharper note, and with rather high " chirr " note interposed.

March 7, 1911.—65° 00′ S., 161° 22′ E. Several terns like those seen on March 4, only the back and wings were almost white in some specimens. They were continually calling, having a large variety of notes. The sandpiper notes were the most generally used, as also a note like that made by a small bird (say a robin) when its nest is approached—a rather querulous single note, often repeated. In the afternoon two more terns of the same species were seen. This evening they were uttering a note very much like a swift's, and reminded me at once of swifts very high up, although the terns were really quite close. One bird would utter this note, while the other kept up a continued twittering. These may possibly be courting notes as the two birds were generally to be seen chasing each other.

4. *Gygis alba alba* (White Tern). Plate VI, figs. 3 and 3*a*.

Sterna alba Sparrman, Mus. Carlson, fasc. i, No. 11, 1786 ; Sharpe, " Birds of South Trinidad," *Ibis*, 1904, p. 217 ; *Gygis candida* Saunders, Cat. Birds Brit. Mus. xxv, p. 149, 1896 ; *Gygis crawfordi* Nicoll, Bull. Brit. Orn. Club, xvi, p. 102, 1906 (South Trinidad).

MATERIAL OBTAINED

No. 17.	♂ S. Trinidad.	28.vii.1910.	E.A.W.	Brit. Antarct. Exped.
No. 18.	♂ ,,	28.vii.1910.	,,	,, ,, ,,
No. 19.	♂ ,,	28.vii.1910.	,,	,, ,, ,,

The following notes on this White Tern, made during the voyage to the Cape, are from Dr. Wilson's diary :—

July 17, 1910.—About 500 miles N.W. of Ascension Island. A White Tern seen, probably *Gygis alba.* (Mr. Nicoll has shown that the Atlantic species is distinct from *G. alba* and has called it *G. crawfordi.*)

July 25, 1910.—19° 27′ S., 29° 14′ W. (Near South Trinidad Island.) The White Tern came off in some numbers as soon as we sighted South Trinidad.

July 26, 1910.—South Trinidad Island. The White Tern was as familiar as before and came flying round us full of inquisitiveness. We found a great many of this species sitting on a single egg. Sometimes the egg was placed on a bare rock or on a boulder, or on a limb of one of the dead trees. There were also numerous young chicks of all ages, from the egg to the young fully fledged bird

that was able to fly twenty yards at a time and which seemed to know what fear of man meant much better than its parents.

A very noticeable point about these young terns was their extraordinary power of holding on to the smooth rock surface by the tips of their small and very sharp claws. Even a chick just hatched stuck to the rock like a limpet and required some force to remove it. This is evidently the result of high winds and the peculiar position of the egg and young. One is led to wonder why the tern should lay its solitary egg in such unsafe positions and the omnivorous land-crabs immediately suggest themselves as the enemy to be avoided, but we saw a sitting tern and a land-crab in very close proximity on a rock and neither taking the slightest notice of the other. Yet one cannot help thinking that this crab would enjoy an egg, though it appears to be a vegetarian in its diet and even climbs the bushes for berries growing on them.

Lt.-Commander Pennell, R.N., also made some interesting observations, which are as follows :—

July 26, 1910.—South Trinidad Island. Tarsi and toes bluish-white (not dark brown), webs pinkish. It never lays more than one egg and used no material for the nest. The young were in various stages of advance and were about equally numerous with the eggs. The young have a greyish down and when frightened crouch down and look very much like the rock they are on. They are nice quiet little birds as they fly or mate with a little squawking chatter, just a few notes at a time and very quiet. These notes remind me of a swallow's chatter without its song. They also have a quiet garrulous sort of note, rather like a gull's only quieter. This was used when two old birds met. On the whole they are quiet birds, all the notes being low. They have an occasional sharp note of fright. We found no chick or egg above 1,200 feet, although a few old birds were flying about the top, 1,900–2,000.

5. *Catharacta skua intercedens* (Kerguelen Skua).

Catharacta lonnbergi intercedens Mathews, "Birds of Australia," ii, p. 494, 1913 (Kerguelen); *Megalestris antarctica* (partim) Saunders, Cat. Birds Brit. Mus. xxv, p. 319, 1896.

The following records made by Wilson and Pennell apparently refer to the subspecies of the Great Skua which breeds on Kerguelen Islands :—

Sept. 13, 1910.—38° 57′ S., 28° 43′ E.,—East of Cape Colony. One flew by the ship in the early afternoon.

Sept. 22, 1910.—38° 58′ S., 80° 37′ E.,—S.E. of Cape of Good Hope. One seen.

Sept. 23, 1910.—39° 15′ S., 83° 33′ E. One seen ; moulting.

Sept. 28, 1910.—40° 57′ S., 97° 26′ E.,—E. of Kerguelen. White bars on the wings, appear to be old feathers.

Sept. 29, 1910.—41° 24′ S., 99° 57′ E.,—E. of Kerguelen. With white markings on the extremities of the wings as before.

Sept. 30, 1910.—41° 59′ S., 102° 54′ E. (E. of Kerguelen.) Seen quite close, a bird moulting several feathers with a cleft in the wing. The white marks on the wings most distinct and although perhaps increased by worn feathers appear to constitute a white bar on each wing. Four seen.

Oct. 1, 1910.—42° 13′ S., 104° 56′ E. (E. of Kerguelen.) Four seen.

The Skuas of the genus *Catharacta* (*Megalestris* of the Catalogue of Birds, Brit. Mus. 1896, xxv) would seem at first sight to fall into two groups, corresponding roughly with a geographical distribution which is either more northerly or more southerly. In so far as a definite line of distinction can be drawn between these two groups each is characterised by the presence or absence of a factor giving rise to a dominant colour-tone in the plumage.

Thus, in the more northerly group the dominant colour-tone is one which has been produced by a factor giving rise to a general tone of cinnamon or cinnamon-red; while in the extreme southerly area of distribution of the genus this factor is either absent or is represented by one giving rise to various shades of brown intensifying to black or almost black. Thus, as far as colour-factors are concerned the genus would appear to be geographically di-chromatic.

To what extent this geographical segregation of colour-factors can actually be delimited or defined seems at present very difficult to gauge, in view of the paucity of the right kind of material at our disposal, due to unscientific collecting in the past; but as far as one can gather, the general rule seems to be for the downy chicks of the more northerly group to moult directly into teleoptiles which are conspicuously tipped, or strongly suffused, with cinnamon-red; while in the extreme southerly range of the genus they would appear, judging from an example in the Royal Scottish Museum collected in the South Orkneys, to moult directly into a teleoptile of a uniform dark slaty-brown.

There would appear, however, to be evidence that the dichromatic distinction is not so simple or so completely correlated with geographical distribution as the above remarks would suggest; for we have examined a chick in down from the Shetland Islands (Scotland) in which the teleoptiles show no trace whatever of the red factor, and this is paralleled by a single specimen in the British Museum of an immature (? first winter) Skua picked up dead in Oxfordshire, which also completely lacked the factor for red. This last bird resembles, in its uniformly brownish-black coloration, the small negroid examples from the extreme south, and in fact can be almost exactly matched by an example in the British Museum from the South Shetlands (1924.5.8.7).

There seems, moreover, to be something approaching an intermediate geographical area represented by various South Atlantic and Indian Ocean islands in which the chromatic factor tends also to be intermediate. For instance, in the Falklands and South Georgia, chicks and juveniles as regards the factor for red fall definitely into the northern category. Doubtless they also do in Tristan d'Acunha, Inaccessible, Nightin-

gale, and Gough Islands, as well as in Kerguelen and such islands as the Crozets and Possession, although we have seen no chicks in down from any of these last. We think this is so, however, because subsequent plumage phases following the juvenile are similar to those obtaining in the Falklands. The phase, for instance, which follows the juvenile (? second year), judging from examples from all the islands just mentioned, is peculiar in this that the feathers of the upper parts are similar to skuas of the far north in colour-tones and colour-patterns, but as regards underparts the factor for cinnamon-red seems to be absent or nearly so, and we get a slaty-brown coloration. As far as material enables one to say, this holds good in all the islands mentioned except Kerguelen, where, curiously enough, both upper and lower parts resemble examples from the Faroes, Iceland, and Shetlands. Furthermore, whereas Skuas from the extreme northerly range of the genus (Iceland, Faroes, Shetlands) and from the west coast of South America (Chile and Patagonia) exhibit, with the rare exceptions already noted, a complete dominance of red colour throughout every phase of feather growth, from chick to fully adult, examples from the intermediate areas, just referred to, lose all trace of red in the fully adult phase of plumage and approximate very closely in appearance to birds from such areas as the South Shetlands and South Orkneys, or the New Zealand islands (Macquarie, Campbell, Chathams, etc.). In view, however, of the inadequate material at our command we would not lay too much stress on the limits, or even the actual existence, of this intermediate group, for immature examples (? second year) from Macquarie Island in the British Museum, although considerably faded, undoubtedly retain the red colour and the colour pattern characteristic of the distal ends of the feathers of the upper parts in the northern Great Skua. On the whole, however, it can be said that one can trace a more or less definite segregation of colour-factors which are correlated with geographical areas. Such a segregation has, in the past, usually been regarded as sufficient justification for specific separation. For instance, the Great Skua of the New Zealand islands, together with those from the South Shetlands and South Orkneys, have been separated under the specific name of *C. lonnbergi*, and this seemed perhaps to have been all the more justified by reason of their generally more massive build, and of certain slight differences in the less saturation of the acuminate feathers of the neck with the " straw colour " characteristic of maturity. So also the birds from the Falkland and other South Atlantic islands have been separated as *C. antarctica*, or alternatively, referred as a sub-species to *C. skua* of the north ; while the form found along the west coast of South America has been recognised as another species, *C. chilensis*. But the frontiers, so to speak, along which lines can be drawn separating one so-called species from another are difficult to define, vague, and unsatisfactory. That this is so is shown by the fact that Mathews regards the Kerguelen Island form as a sub-species of *C. lonnbergi* under the name *C. lonnbergi intercedens*, although on the evidence of examples in the British Museum it is difficult to see how it can be separated *specifically* from Falkland and South Atlantic island forms which, in turn, Mathews regards as sub-species of *C. skua*.

We are, therefore, reluctant to commit ourselves, while awaiting the arrival of more comprehensive series of skins, representative of all forms in every phase of plumage from chick to adult, as well as of adults in winter and summer plumage. At the same time we are still strongly of the opinion that on the present evidence there seems little justification for regarding all the forms we have been discussing as anything more than sub-species or chromatic segregates of but one species, viz. *Catharacta skua.*

A word should perhaps be added here in connection with McCormick's Skua of the extreme south. It will doubtless be considered by some ornithologists somewhat ruthless not to have excluded, on the grounds of specific distinction, this skua from the group we have been considering. And indeed, if we compare examples of *C. skua* from Iceland and the Faroes with examples of McCormick's Skua taken from Antarctica, the differences at first sight seem so striking as to suggest specific diversity. When, however, we come to a more critical comparison we not only find a more or less complete series of intermediates between these two extreme forms, but that, after all, no new element has been introduced and that the differences obtaining between the characters exhibited by both forms are concerned with the presence or absence of factors in more or less pronounced or saturated form.

It is to be noted that in McCormick's Skua there is not the faintest trace of the factor for cinnamon-red or cinnamon-brown in the whole series of plumage phases from downy chick to fully adult; so that it would appear that this species represents one extreme and either the European or the Chilian form the other.

After an examination of a large series of skuas contained in the British, Royal Scottish, Tring and Copenhagen Museums we consider that the different sub-species of the Great Skua may be provisionally arranged as follows:

Catharacta skua skua (Brünn). Iceland, Faroes, Shetland, S. Greenland, etc.
,, ,, *chilensis* (Bp.). Coast of S. America: Rio de Janeiro to Peru.
,, ,, *antarctica* (Lesson). Falkland, Gough, Inaccessible and Tristan da Cunha Island.
,, ,, *clarkei* (Mathews). S. Orkneys, S. Shetlands, and South Georgia.
,, ,, *lonnbergi* (Mathews). Australia, New Zealand and Subantarctic Islands.
,, ,, *intercedens* (Mathews). Kerguelen.
,, ,, *maccormicki* (Saunders). Victoria land, South Shetlands and Antarctic Seas.

MEASUREMENTS OF *CATHARACTA SKUA ANTARCTICA*.

FALKLAND ISLANDS AND TRISTAN GROUP.

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	†Length of Bill.	‡Depth of Bill.	Length of Tarsus.	Notes.
			Falkland Islands	*Ex* Howard Saunders Coll. ..	394	49	20	67	
Tring Museum	♀	21.i.1921	,, ,, ...	A. G. Bennett	389	50	21	68	
,, ,, ...	♀	10.ii.1921	,, ,, ...	,, ...	388	52	21	69	
,, ,, ...	0		,, ,, ...	Messrs. Rowland Ward ..	385	51	19	69	
*1891.5.22.61	♀	15.iv.	,, ,, ...	*Ex* Salvin-Godman Coll. ..	380	48	20	69	
			,, ,, ...	*Ex* Howard Saunders Coll. ..	377	47	20·5	69	
Tring Museum	♀	6.ii.1921	,, ,, ...	A. G. Bennett	377	50	21	69	
,, ,, ...	♂	5.iii.1921	,, ,, ...	,, ...	372	51	20	69	
1891.5.22.60	0		,, ,, ...	*Ex* Salvin-Godman Coll. ..	370+	47	20·5	66·5	
Tring Museum	♂	12.ii.1921	,, ,, ...	A. G. Bennett	370	49	21	68	
1880.11.18.735	♀		,, ,, ...	Challenger Expedition ..	368	47	20·5	69	
		1875	,, ,, ...	*Ex* Howard Saunders Coll. ..	365	48	20	68	
Royal Scottish Museum ..	0		,, ,, ...	.. ..	382+	46		70	
Tring Museum	♀	24.i.1904	Tristan da Cunha	H.M.S. "Odin"	390+	55	22	72	
,, ,, ...	♂	25.i.1904	,, ,, ...	,, ...	385+	53	21	70	
,, ,, ...	♀	25.i.1904	,, ,, ...	,, ...	380	54	22	71	
1922.12.6.33	♂	31.v.1922	Gough Island	G. H. Wilkins	385	50·5	20·5	73	Iris dark brown; bill black; feet blackish-brown.
1922.12.6.34	♀	31.v.1922	,, ,, ...	,, ...	396	53·5	24	75·5	Iris light brown; bill and feet black.
Royal Scottish Museum ..	♂	22.iv.1904	,, ,, ...	.. ..	373	51		69	
,, ,, ,, ..	0	22.iv.1904	,, ,, ...	.. ..	389	54		75	
1922.12.6.35	♂	21.v.1922	Nightingale Island ..	G. H. Wilkins	381	52	22	73·5	Iris dark brown; bill black; feet blackish-brown.
1845.7.6.68	0		Cape of Good Hope ..	Sir Andrew Smith	405	51	22	81	

* British Museum specimens denoted by registered numbers. † From feathers on forehead to tip. ‡ Greatest depth at base.

MEASUREMENTS OF *CATHARACTA SKUA CLARKEI.*

SOUTH ORKNEYS

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
Royal Scottish Museum ..	0	4.i.1904	North Beach, S. Orkneys..	.. ..	410	44		77	
" " " ..	0	5.xi.1903	" " ..	.. ..	411	52	24	76	
" " " ..	0	xi.1903	" " ..	.. ..	412	46		72	
" " " ..	0	18.ii.1904	" " ..	.. ..	412	52		77	
" " " ..	0	xi.1903	" " ..	.. ..	419	52		73	
" " " ..	0	x.1903	" " ..	.. ..	401	50		72	
" " " ..	0	ii.1903	" " ..	.. ..	411+	53		72	
" " " ..	0	xi.1903	" " ..	.. ..	406	52		74	
" " " ..	0	xi.1903	" " ..	.. ..	415	49		78	
" " " ..	0	xi.1903	" " ..	.. ..	418	49		79	
" " " ..	0	xi.1903	" " ..	.. ..	406	51		71	
" " " ..	0	iii.1903	" " ..	.. ..	403	53		76	
" " " ..	0	xi.1903	" " ..	.. ..	422	56		78	

SOUTH GEORGIA.

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
1922.12.6.36	♀	25.xii.1921	Elsa Harbour, South Georgia	G. H. Wilkins	422	52·5	22·5	77	Iris dark brown; bill and feet dark reddish-brown.
Tring Musem	0		S. Georgia	German Antarctic Expedition	421+	58	23	77	
1914.3.8.48	♂	12.xi.1913	King Edward's Cove "	P. Stammwitz	414	49	22·5	72	
1914.3.8.49	♂	14.xii.1913	" " " "	"	403	54	22	76	
Tring Museum	♀	21.v.1922	Elsa Harbour, "	G. H. Wilkins	400	55	22	75	
" "	♂	25.xii.1921	" " "	"	401+	54	22	75	
" "	0		S. Georgia	German Antarctic Expedition	397	56	24	76	
1922.12.6.32	♂	25.xii.1921	Elsa Harbour "	G. H. Wilkins	396	50	22	74	
1914.3.8.50	♂	14.xi.1913	King Edward's Cove "	P. Stammwitz	395	52	23	71	

SOUTH SHETLANDS

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
1924.5.8.85	♂	16.xii.1920	South Shetlands	J. E. Hamilton	415	52	23	75	
1923.9.10.2	♂	12.xii.1922	Deception Islands ..	A. G. Bennett	414	48	21	72	
1924.5.8.86	♂	24.xii.1922	,, ,, ..	J. E. Hamilton	410	50·5	22	75	
1924.5.8.83	0	xi.1923	,, ,, ..	,, ...	400	50	22	72	
1924.5.8.10	♀	3.ii.1922	Port Lockroy, Palmer Arch.	,, ...	393	44	19	64	
1924.5.8.8	♀	26.xii.1923	South Shetlands	,, ...	392	49	22	73	
1924.5.8.4	0	xi.1923	,, ,, ...	,, ...	392	46·5	20	66	
1923.9.10.1	0	24.ii.1922	Deception Islands ..	A. G. Bennett	387	50	19	63	
1924.5.8.7	♀	26.xii.1923	,, ,, ...	J. E. Hamilton	381	46	19	68	
1924.5.8.9	♂	26.xii.1923	,, ,, ...	,, ...	375	47	18·5	65	

MEASUREMENTS OF *CATHARACTA SKUA INTERCEDENS.*

KERGUELEN AND CROZETS

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
1909.11.16.9	♀	xii.1907	Possession Island	Capt. Th. King	422	57·5	22	77·5	
Tring Museum	♀	28.xii.1897	Kerguelen	Hall	414	57	22	76	
1841.768	0	13.vi.1840	Christmas Harbour, Kerguelen	R. McCormick	410	52	23	78	
1876.4.26.22	0		Royal Sound, Kerguelen ..	A. E. Eaton	406	57	24	78	
1909.11.16.8	0	i.1908	Possession Island	Capt. Th. King	403	49·5	20·5	71·5	
1880.11.18.734	0	i.1874	Kerguelen	"Challenger" Expedition ..	402	54	22·5	74	
1841.767	0	20.v.1840	Christmas Harbour ..	R. McCormick	401	53·5	22	74·5	
Tring Museum	♂	5.i.1898	Kerguelen	Hall	398	56	22	75	
1891.6.16.8	0	15.v.1840	Christmas Harbour ..	R. McCormick	395+	54	22	76	
1880.11.18.734	0	16.x.1873	Kerguelen	Challenger Expedition	395	50	20	73·5	

MEASUREMENTS OF *CATHARACTA SKUA LONNBERGI.*

NEW ZEALAND AND SUB-ANTARCTIC ISLANDS

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
1905.12.30.177	♀	22.xi.1901	Macquarie Island ..	"Discovery" Exped.—E. A. Wilson	447	55	26·5	79	
1905.12.30.178	♀	"	" " ..	" " "	435	56	25	79·5	
1905.12.30.172	♂	"	" " ..	" " "	424	53	22·5	76	
1905.12.30.167	♂	"	" " ..	" " "	423	51	23	95	
1905.12.30.168	♂	"	" " ..	" " "	421	55	24	78·5	
Tring Museum	0		" " ..	" " "	420	59	24	78	
" "	0		" " ..	" " "	415	56	23	76	
" "	♀	iii.1894	Campbell Islands	Dannefard	434	56	23	80	
1901.1.7.55	0	20.x.1899	" "	"Southern Cross" Exped.—N. Hanson	433	51	24	80	
1891.6.16.44	0	6. xii. 1840	" "	Dr. R. McCormick	431		23	84	
1891.12.16.51	0	xii.1840	" "	Antarctic Expedition	419	53	24	78	
1891.6.11.15	0	xii.1840	" "	Lt. A. Smith	395+	53	24	84	
1903.3.20.3	0		" "	Lt. Kenneth Dixon		56	23	83	
Tring Museum	♀		Auckland Island		437	57	24	80	
1897.12.6.41	♀		" "	Otago University Museum ..	430	54	24	79	
1893.6.24.1	0		Chatham Islands	H. O. Forbes	443	51·5	22	75	
Tring Museum	0		" "	Palmer	420	55	25	79	
" "	♀		" "	*Ex* G. M. Mathews's Collection	418	57	23	78	
" "	0		" "	Palmer	411	57	22	78	
" "	♀		" "	Dannefard	410	55	21	78	
" "	♀		" "	"	407	57	23	77	
" "	0		" "	Palmer	407	57	23	82	
" "	♀		Norfolk Island	Rayner—*Ex* G. M. Mathews's Coll.	424	58	25	82	
" "	♂		New Zealand	*Ex* Mathews's Coll. (Type of *C. ant. lonnbergi*, Mathews).	442	56	24	77	
1851.7.18.34	0		" "	Sir G. Grey	431			81	
1892.4.15.1	0	2.iv.1892	Seas, Cape to N.Z. ..	R. B. Marston	429	52·5	23·5	80	
1843.7.11.38	♀		36° 8′ S., 88° 55′ E. ..	Sir G. Grey	425+	48	23	74	
Tring Museum	♀	1905	New Zealand Seas ..		437	56	25	81	

SUMMARY

	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.
Falklands Islands	394–365	52–47	21–19	69–66·5
Tristan da Cunha and Gough Island ..	396–380	55–50·5	24–20·5	75·5–70
South Orkneys	422–401	56–46	—	79–71
South Georgia	422–395	59–49	24–22	77–71
South Shetlands	415–375	52–46	23–18·5	75–63
Kerguelen	422–395	57·5–49·5	24–20	78–71·5
New Zealand area	447–395+	59–48	26·5–21	84–74

6. *Catharacta skua lonnbergi* (New Zealand Skua).

Catharacta antarctica lonnbergi Mathews, Nov. Zool. xviii, p. 212, 1912 (New Zealand Seas); *Megalestris antarctica* (partim) Saunders, Cat. Birds Brit. Mus. xxv, p. 319, 1896.

The extracts which are given below from Dr. Wilson's and Commander Pennell's diaries we consider to refer to the New Zealand race of the Great Skua, which, as far as we know, has not been observed so far south before.

Sept. 25, 1910.—46° 30′ S., 116° 07′ E., South of King George Sound, S.W. Australia. One flying round the ship early this morning for an hour or two.

Nov. 29, 1910.—Off Port Chalmers. One seen.

Feb. 20, 1911.—N. of Cape Adare. Heavier birds than McCormick's Skua and darker altogether, but owing to the great variation in the latter cannot be logged with certainty.

Feb. 21, 1911.—68° 41′ S., 168° 29′ E. Seen. Easily recognised by their heavier build.

Feb. 22, 1911.—69° 10′ S., 164° 30′ E. Seen.

Feb. 23, 1911.—69° 29′ S., 162° 48′ E. Four seen together on and above one floe.

March 18, 1912.—64° 03′ S., 160° 12′ E. Larger and darker than McCormick's.

Dec. 15, 1912.—Off New Zealand coast. Seen.

Dec. 17, 1912.—49° 12′ S., 178° 14′ E. Three seen.

Feb. 6, 1913.—54° 22′ S., 164° 49′ E. Seen.

Feb. 8, 1913.—Off East coast New Zealand. Seen.

7. *Catharacta skua maccormicki* (McCormick's Skua).

Stercorarius maccormicki Saunders, Bull. Brit. Orn. Club, iii, p. 12, 1893 (Victoria Land); *Megalestris maccormicki* Saunders, Cat. Birds Brit. Mus. xxv, p. 321, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 64, 1907; *Catharacta maccormicki wilsoni*, Mathews, "Birds of Australia," ii, p. 495, 1913 (Coat's Land).

MATERIAL OBTAINED

No. 53. December 22, 1910. Pack-ice, 68° 41′ S., 179° 28′ W. A. Cherry-Garrard. Weight 3 lbs.

—. ♂ Cape Adare. 20.xi.1911. G. Murray Levick.

No. 136.	♀ Cape Evans.	31.xii.1912.	A. Cherry-Garrard.	Weight	2 lbs. $14\frac{3}{4}$ oz.
No. 137.	— ,,	31.xii.1912.	,, ,,	,,	2 lbs. 12 oz.
No. 138.	♂ ,,	31.xii.1912.	,, ,,	,,	3 lbs. $\frac{1}{2}$ oz.

On December 7, 1910, 61° 22′ S., 179° 56′ E., Wilson writes in his diary :—" One with a distinctly paler body than in *C. antarctica* and rather smaller in size. I feel pretty certain as to the identification." Five days later in 67° 28′ S. another was seen of which there was no doubt about the identification, and there are notes of single birds up to January 4, 1911, in 75° 3′ S., 173° 41′ E. When five miles East of Cape Crozier on January 4, Wilson notes McCormick's Skua was very abundant as was the case also in McMurdo Sound, and between January 6 and 11 he made the following interesting observation at Cape Evans :—" Very abundant, some still hatching eggs, and I found two in one nest. Some had young chicks just hatched or just hatching. One nest had one young chick hatched out and one just breaking out of the egg the day we landed. This was at Cape Evans, which we used to call the Skuary. The birds were as usual bathing in the freshwater lochs there."

Commander Pennell has a number of records of this Skua in the zoological log of the " Terra Nova." After leaving Cape Evans it was seen occasionally up till March 4 in 67° 11′ S., 160° 47′ E., S.W. of Balleny Islands.

On the voyage south again in December, 1911, there is an entry in the log for the 27th, 64° 56′ S., 175° 30′ W. : " Skua Gulls—Appeared to be large and dark, probably Antarctic Skua Gull," which doubtless refers to the previous species. From January 3, 1912, when off Cape Adare, till January 18, in 77° 21′ S., 164° 12′ E., McCormick's Skua was seen almost daily, and on January 20 the entry in the log is as follows :—" The noise made by the Skuas as they quarrel over food is almost identical with that of a flock of ducks in a farmyard. McCormick's Skua and Adelie Penguins are always with us, and therefore not logged." The last bird seen on this voyage was on March 16 in 66° 44′ S., 164° 48′ E.

On the final journey south there are only four entries in the log, and all in latitudes in which this Skua was seen on the previous voyages.

Systematic Notes.—Two examples of this Skua were obtained by the " Scotia " Expedition in the Weddell Sea and these Mathews has described as a separate race—*C. s. wilsoni*—on account of their smaller size. We have examined these two birds and M. Berlioz of the Paris Museum has sent us the measurements of seven obtained by Dr. Charcot's Expedition in the South Shetlands. As will be seen from the accompanying table they are, on the average, slightly larger, not smaller, but the difference does not seem to us sufficient to warrant separation as a separate race.

MEASUREMENTS OF *CATHARACTA SKUA MACCORMICKI.*

ROSS SEA AREA

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Length of Wing.	Length of Bill.	Depth of Bill.	Length of Tarsus.	Notes.
1905.12.20.277	♂	iii.1903	McMurdo Strait	"Discovery" Exped. E. A. Wilson (C.)	415+	51	21	62	
1905.12.20.247	♂	xii.1902	" "	" " "	404	51		64	
1916.6.20.84	♂	31.xii.1912	Cape Evans	"Terra Nova" Exped. A. C. Garrard (C.)	410	48	19	66	
1901.1.7.51	♂	14.i.1900	Cape Adare	"Discovery" Exped. E. A. Wilson (C.)	387	48	20	63	
1905.12.20.273	♂	15.i.1903	McMurdo Sound	" " "	398+	48		61	
1916.6.20.85	♂	22.xi.1911	Cape Adare	"Terra Nova" Exped. G. M. Levick (C.)	391	47	21	63	
1905.12.20.349	♀	xii.1902	McMurdo Sound	"Discovery" Exped. E. A. Wilson (C.)	407+	50	17	67	
1905.12.20.281	♀	31.i.1902	Great Ice Barrier	" " "	401+	50	18	66	
1901.1.7.50	♀	6.xi.1899	Cape Adare	"Southern Cross" Exped. N. Hanson (C.)	410	49	21	67	
1916.6.20.82	♀	31.xii.1912	Cape Evans	"Terra Nova" Exped. A. C. Garrard (C.)	403	50	18	68	
1901.1.7.	♀	14.i.1900	Cape Adare	"Southern Cross" Exped. N. Hanson (C.)	390+	48	21	65	
1916.6.20.83	♀	31.xii.1912	Cape Evans	"Terra Nova" Exped. A. C. Garrard (C.)	410	48	19	65	

WEDDELL SEA AREA

Reg. No.	Sex.	Date.	Locality.	How Acquired.	Wing.	Length of Bill.	Depth of Bill.	Tarsus.	Notes.
Royal Scottish Museum		9.iii.1904	74° S., 22° W. Off Coats' Land	"Scotia" Exped. Type of *C. maccormicki wilsoni* Math.	380	48·5	21·5	59	
" " "		10.iii.1903	66° 40′ S., 40° 35′ W. Weddell Sea	"Scotia" Exped.	410	49	21	62	
Paris Museum	♂	2.xii.1909	Deception Is., S. Shetlands	Charcot's Exped.	406	53	23		
" "	♂	30.i.1909	Jenny Is., "	" "	386	46	19		
" "	♀	2.xii.1909	Deception Is., "	" "	427	50·5	23		
" "	♀	8.i.1909	Cape Tuxen "	" "	401	45	21		
" "	♀	28.ii.1909	Petermann Is., "	" "	401	45	20		
" "	♀	28.ii.1909	" "	" "	401	46	21		
"	♀	28.ii.1909	" "	" "	401	48	20		

8. *Oceanodroma castro* (Madeiran Fork-tailed Petrel). Text-fig. 7.

Thalassidroma castro Harcourt, "A Sketch of Madeira," pp. 123, 166, 1851 (Dezerta Island, Madeira); *Oceanodroma cryptoleucura* Salvin, Cat. Birds Brit. Mus. vol. xxv, p. 350, 1896.

In his notes Dr. Wilson identified this bird as *Cymochorea leucorhoa,* but from the sketch he made of it there is little doubt but that it is *Oceanodroma castro,* which breeds in the Azores, Salvage Islands, Madeira Group and Cape Verde Islands, and possibly on St. Helena.

July 9, 1910.—11° 20′ N., 24° 37′ W., South of Cape Verde Islands. At 7 a.m. I saw two small petrels of the smaller type some way off. Black with white rumps

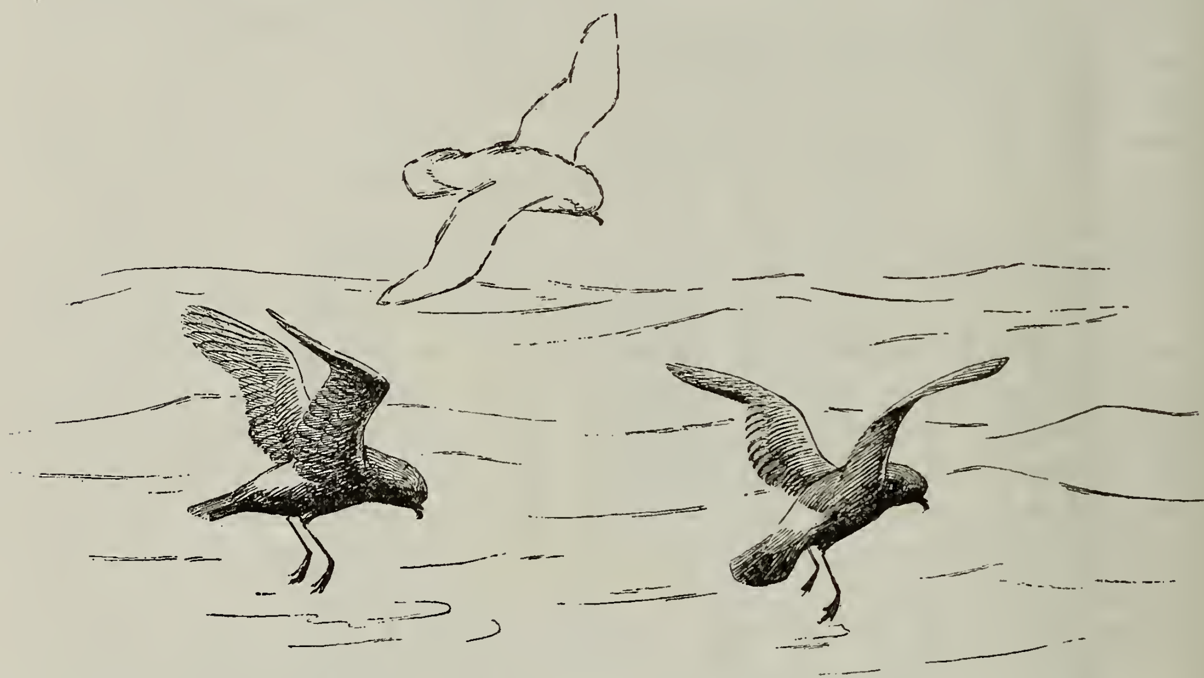

Fig. 7.—Madeiran Fork-tailed Petrel (*Oceanodroma castro*). Feeding.

apparently all black underneath, so possibly *C. leucorhoa* (?); but the flight was quite distinct from that of the birds of July 6 (cf. *Bulweria bulwerii*); nor can I think it was the same bird. The two birds seen this morning were on the feed and settled on the water with outspread wings, then paddled along and half sat on the water again, and so on.

9. *Oceanites oceanicus* (Wilson's Petrel). Text-figures 8 and 9.

Procellaria oceanica Kuhl, Beitr. Vergl. Anat. p. 136, 1820 (South Atlantic Ocean); *Oceanites oceanicus* Salvin, Cat. Birds Brit. Mus. xxv, p. 358, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 76, 1907.

On June 19, 1910, in 43° 54′ N., 12° 48′ W., West of Cape Finisterre, Dr. Wilson records this Petrel in his diary as follows:—"Several in the water all day. Never

more than three or four during the day time, but towards sunset more gradually collected in the water until it became too dark to see them. They fly as a rule very close to and along the contour of every little wave, with outspread wings, very seldom flapping, but every now and again dropping the feet to touch the water and then picking up some small crustacean (?) from the surface. The wings of every one of these birds had two or three primaries missing—one could see the gap —and the coverts were bleached and pale brown, making a pale-coloured bar across the wings. Obviously moulting. The feet, when the bird is on the wing, project about $\frac{3}{4}$ inch beyond the tail (see Text-fig. 8), giving the tail a cuneate form which it does not really possess, the tail being cut across more or less square. These birds are very faithful to the wake and they wander but little from it, and to-day when we saw what was apparently a *P. pelagica* flying in wide sweeps about the bows we judged it was a different species. In my old notes ('Discovery') I found the same habit mentioned, and in the margin some one had written ? 'Leach's Petrel.'"

Fig. 8.—Wilson's Petrel (*Oceanites oceanicus*). Side and dorsal view to illustrate the feet extending beyond tail.

No more apparently were seen till December 8, in 63° 20′ S., 177° 22′ W., when this species was again observed and after that date this bird was seen nearly every day till January 3, when the "Terra Nova" was within 24 miles of Cape Crozier.

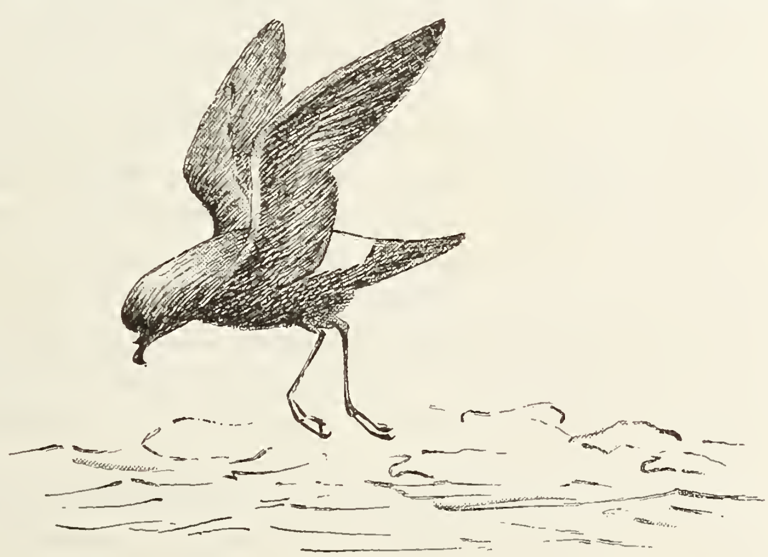

Fig. 9.—Wilson's Petrel (*Oceanites oceanicus*). Feeding among the "brash" ice.

Dr. Wilson in his diary has entries such as :—"One or two every now and again," "a few," "two or three seen," "two or three singly." He was again impressed with the resemblance of this petrel to a house martin, and under the date of December 13 writes :—"One bird flying round high up in snow-storm. The species looked more than ever like a House Martin flying round in the falling snow."

On December 16 he records in his diary :—"One, feeding as it flitted over scraps of 'brash' ice, which appeared to catch the small crustaceans on the windward side, as they were blown along the open water pools" (Text-fig. 9).

Commander Pennell observed this bird as far north as 64° 23′ S., 161° 39′ E., on March 8, on his voyage north, and during his other voyages recorded Wilson's Petrel on different occasions.

On the "Terra Nova's" voyage south from New Zealand Wilson's Petrel was first seen on December 8 in 63° 20′ S., 177° 22′ W., and after that date Dr. Wilson recorded this bird in his diary nearly every day till January 3, when the ship was within 24 miles of Cape Crozier.

10. *Fregetta tropica melanogaster* (Eastern Black-bellied Storm Petrel).

Thalassidroma melanogaster Gould, Ann. & Mag. Hist. xiii, 1844, p. 367 ("S. Indian Ocean" —Agulhas Bank, S. Africa—Gould); *Cymodroma melanogaster* Salvin, Cat. Birds Brit. Mus. xxv, p. 364, 1896 [part]; *Fregetta melanogaster* Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 79, 1907 [part].

MATERIAL OBTAINED

No. 31. ♀ December 8, 1910. 39° 56′ S., 32° 12′ E. A. Cherry-Garrard Coll. Bill black; legs and feet black; iris very dark brown.

Gould said in his original description (*loc. cit.*) that this species was very abundant in the South Pacific and the South Atlantic, but subsequently in his "Birds of Australia" he gives further details and states that his first acquaintance with it commenced on August 12, 1839, when off Cape Agulhas (southernmost point of Africa). The region where this bird was taken by Mr. Cherry-Garrard approximates to Gould's amended topo-typical locality for his *Thalassidroma melanogaster*, but the birds seen and described by both Wilson and Pennell in the region of Ascension Island were in all probability *Fregetta tropica tropica*, which appears to be a form restricted to the Atlantic Equatorial zone. It should be noted, however, that both birds have a longitudinal median band, and we doubt if a distinction between the two forms could be drawn at sea.

A good deal of confusion seems to have existed in the past in regard to the nomenclature and distribution of the various species and races of the group of small petrels to which the bird under discussion belongs. The group appears to comprise a rather natural association of small "black and white Storm Petrels," which, although somewhat closely allied to such genera as *Oceanites*, *Pelagodroma*, *Oceanodroma*, *Halocyptena*, *Thalassidroma*, *Cymochorea*, and *Garrodia*, are obviously to be distinguished from them by certain superficial structural characters connected with the epidermal covering (*podotheca*) of the legs and feet. One of us has already shown (P.Z.S. 1925, pp. 1433–1443) that this assemblage of small petrels possess certain basi-cranial characters in common, which, in his opinion, justifies their inclusion in a family, Oceanitidae, sharply marked off from all the rest of the Tubinares; while these latter in their turn may be justifiably included in a family, Procellariidae, by the possession in common of other basi-cranial features.

In a general survey of the former family (Oceanitidae), the black and white storm petrels with which we are dealing stand out in clear contrast from all the other genera, and this has been tacitly acknowledged in the fact that since the days of Bonaparte they have been included either under the genera *Fregetta* or *Cymodroma*. Mathews, however, in his " Birds of Australia " (1912, ii, p. 31), proposed a further subdivision of the group comprising Bonaparte's genus *Fregetta* with *Thalassidroma leucogaster* Gould as type ; his own genus *Fregettornis* with *Procellaria grallaria* of Vieillot as type ; and another new genus proposed by him, viz. *Nesofregetta* with Salvin's *Fregetta moestissima* as type. Of these generic appellations *Fregettornis* is a pure synonym of Ridgway's *Cymodroma,* so that according to Mathews we have three genera—*Fregetta, Cymodroma,* and *Nesofregetta.*

Having examined all the material bearing on the subject contained in the collections of the British Museum and of Lord Rothschild at Tring, as well as having considered all the subsequent literature since the publication of Mathews's " Birds of Australia," we have for our part come to the conclusion that the subdivision of the genus *Fregetta* is inadvisable and merely serves to obscure the important fact that the group of small petrels comprised within it are genetically linked by the possession in common of at least two characters which distinguish them from all other petrels of the family Oceanitidae.

It is perfectly true that the reasons brought forward by Mathews for a further subdivision of the genus *Fregetta,* in his close and able criticism of this group, are based upon differential characters which undoubtedly exist. For example, the species of his restricted genus *Fregetta* are characterised by the possession of a booted tarsus, while in those of his restricted *Cymodroma* they are scutellated. Or again, the toes of his *Fregetta* are relatively more unequal and longer than in his *Cymodroma ;* but even with the inadequate material at our disposal, there may be traced a transitional series from the nearly equal and short toes seen in *Cymodroma howensis* (cf. Plate, *p.* 1, Mathews, " Birds of Norfolk and Lord Howe Islands," 1928), to the relatively unequal and long toes of *Fregetta tropica,* while the probability seems to be that as more species and sub-species are discovered, existing gaps will be gradually obliterated. We would point out too that the booted tarsus is but the merest step onwards from the non-booted and may apparently be correlated with age, although we do not suggest that in this group of petrels it is. Moreover, it cannot be too strongly insisted that when we come to consider the *pros* and *cons* for uniting or disrupting groups of species the really important facts that systematists ought to bear steadily in mind are not connected with differences but with similarities. If we ask ourselves what similarities are possessed in common by the various species of the group under consideration, the marked compression of the bony phalanges leading to flat toes and a certain type of colour-pattern at once suggest themselves. Unlike other characters they run through the whole group. Unlike other characters they are not met with in other groups of petrels. It is obvious that such similarities indicate some sort of genetic affinity which

may be expressed by their inclusion in one genus *Fregetta*. If, on the other hand, we concentrate our attention on *differences* we shall, it is true, find them ; as, for example, in tails of different shapes, but if we make use of such differences as generic characters it seems equally true that in the process we are in danger of losing sight of the probable fact that all the species composing our restricted genera are linked together by the possession of some common character and ancestor. If this is indeed a fact, it is an important fact which can only be expressed, in our systematic scheme, by uniting them under some common heading.

Nevertheless, although we have stated that in our opinion such a course should be adopted it is important to note that the characters which distinguish Mathews's three genera have a geographical correlation. It is clear that isolation has been an important factor in their evolution. It would be, in our opinion, a regrettable occurrence if "lumping" led to the overlooking or ignoring of the facts which Mathews by his close application has brought out.

11. *Fregetta tropica tropica* (Black-bellied Storm Petrel).

Thalassidroma tropica Gould, Ann. Mag. Nat. Hist. xiii (First series), p. 366, 1844 ("Atlantic Ocean"—"in the vicinity of the line"); *Cymodroma melanogaster* Salvin, Cat. Birds Brit. Mus. xxv, p. 364, 1896 [part]; *Fregetta melanogaster* Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 79, 1907 [part].

The following observations refer to the typical form :—

July 17, 1910.—North-west of Ascension Island. This species appeared for the first time, and was to be recognised at some distance by the amount of white underneath and the distinct longitudinal black band along the belly and breast. I saw one or two, but a few more were seen. Its flight is also more of a dipping flight that that of Leach's Petrel, swinging from side to side.

Lieut.-Commander Pennell notes that it "keeps fairly close to the ship on the beam, skims in the trough of and over the waves, with very little motion of the wings. It has a very piebald appearance, as it has such a large proportion of white below and under the wings which shows when flying."

July 19, 1910.—West of Ascension Island. One was observed in the morning following in the wake, flying with steady outspread wings and a sort of see-saw sideways motion, catching small things on the surface here and there.

July 20, 1910.—10° 7′ S., 24° 52′ W. South-west of Ascension Island. Lieut.-Commander Pennell notes that "its motionless flight is very marked."

12. *Bulweria bulweri* (Bulwer's Petrel). Text-figs. 10 and 11.

Procellaria bulwerii Jard. and Selby, Ill. Orn. ii, pl. 65, 1828 (Madeira); *Bulweria bulweri* Salvin, Cat. Birds Brit. Mus. xxv, p. 420, 1896.

The following notes from Wilson's diary are included, since they give, apparently for the first time, a graphic description of the flight of Bulwer's Petrel:—

June 23, 1910. 32° 56′ N., 16° 37′ W., near Madeira. A wholly black or dark-brown Petrel with long pointed wings—a long way off, but apparently with no trace of white about it anywhere or anything paler than dark brown.

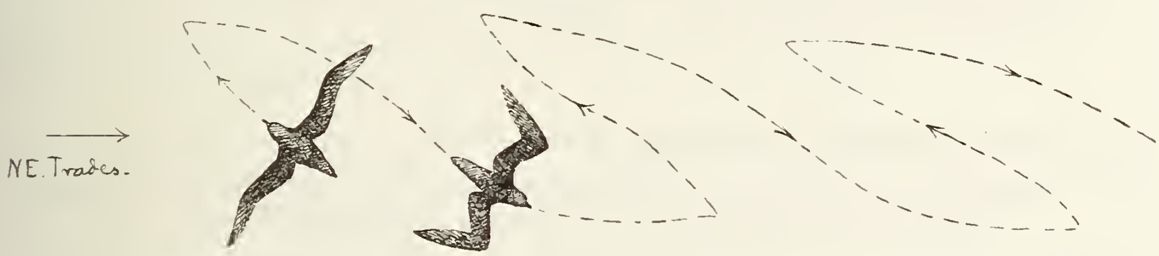

Fig. 10.—Bulwer's Petrel (*Bulweria bulwerii*). Zig-zag flight in north-east wind.

Wilson adds in the margin "? Leach's Petrel (*O. leucorrhoa*)," but as Mr. Ogilvie-Grant pointed out, this bird was almost certainly Bulwer's Petrel.

July 6, 1910. 17° 8′ N., 25° 30′ W. (Fifty miles off San Antonio, to west of Cape Verde Is.) A black Petrel with long narrow and pointed wings, which was

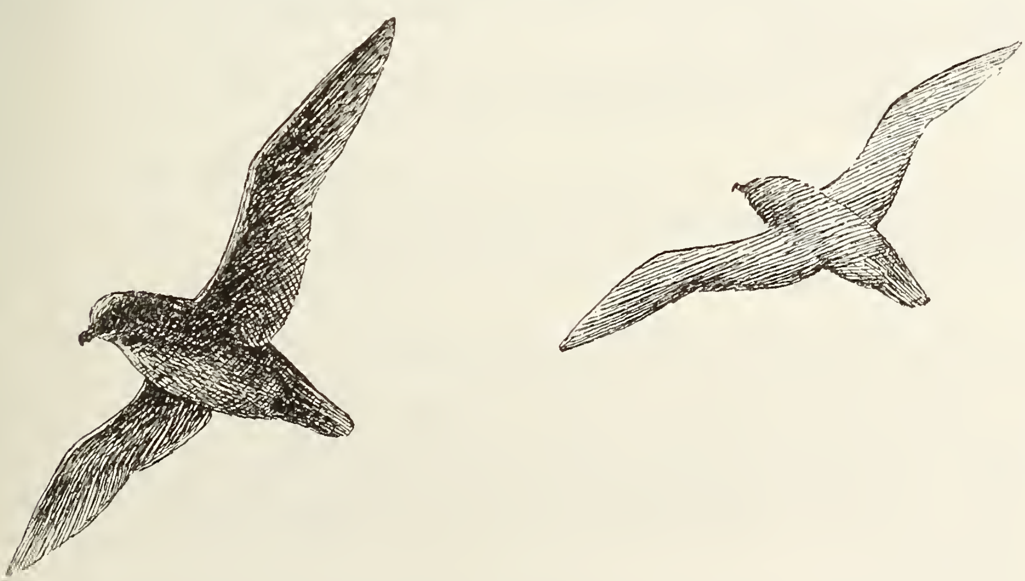

Fig. 11.—Bulwer's Petrel (*Bulweria bulwerii*). Different attitudes in flight.

too far off to see any detail or any white on the rump or other part. It was rather larger than any "Carey's chicken," and flew like a snipe or a sandpiper in a most regular zig-zag, up into the wind and then down into the wave-hollows, backwards

and forwards, exactly like a sandpiper singing its courting song when it flies criss-cross in this fashion.

This Petrel, which I take to be Leach's Fork-tailed Petrel (?), though it was too far off to see for certain any white on the rump, flew up into the wind then down into the wave-trough most rapidly and regularly and most characteristically.

In the wave-trough the bird disappeared for a second or two every dip. The turns were extraordinarily swift, and the bird seemed to turn right over and shoot downwards each time with great rapidity.

July 7, 1910.—15° 38′ N., 25° 24′ W. "Leach's Fork-tailed Petrel (?)," if my view is correct, was round us again to-day. The single specimen was seen by Atkinson, and he described the flight of a black petrel of the same size exactly as I have given it for the bird I saw yesterday.

13. *Puffinus tenuirostris brevicaudus* (Allied Shearwater).

Puffinus brevicaudus Gould, "Birds of Australia," vol. vii, pl. 56, 1847 (Green Is., Bass Straits); *Puffinus tenuirostris* Salvin, Cat. Birds Brit. Mus. xxv, p. 388, 1896 [part].

The following notes of Dr. Wilson's apparently refer to this species :—

Sept. 29, 1910.—43° 48′ S., 146° 01′ E. About noon we came in sight of rocky islets, and a large number of blackish birds came off, probably Mutton Birds.

In the afternoon along the coast of the mainland, the number of the blackish-brown birds, Shearwaters evidently, was enormous. They flew in long spreading flocks, close over the water. When we saw them they were not more than five miles from the coast.

Nov. 29, 1910.—Left Port Chalmers. Many.
Nov. 30, 1910. 47° 34′ S., 170° 38 E. A few.

14. *Calonectris kuhli edwardsii* (Cape Verde Shearwater).

Puffinus edwardsii Oustalet, Ann. Sci. Nat. (6) xvi, Art. 5, p. 1, 1883.

Dr. Wilson noted the Cape Verde Shearwater on two occasions, viz. :—

July 6, 1910.—17° 8′ N., 25° 30′ W. Fifty miles off San Antonio, West of Cape Verde Is. A Shearwater (probably of this species) was flying round the ship most of the forenoon, but very seldom came near enough for identification. It was very long and pointed and narrow in the wings; had all the upper parts grey or grey-brown, also the chin and throat. Rest of the underparts were all white.

July 7, 1910.—15° 38′ N., 25° 24′ W. West of Cape Verde Is. Two Shearwaters—probably *Puffinus gravis*—were flying round the ship half the forenoon. The head was distinctly brown, darker on the crown, and the colour faded up towards the nape. (The birds seen were almost certainly *P. kuhli edwardsii*, which breeds in great numbers on the Cape Verde Is.)

15. *Adamastor cinerea* (The Great Grey Shearwater). Text-fig. 12.

Procellaria cinerea Gmelin, Syst. Nat. i, pt. ii, p. 563, 1789 (Antarctic Circle, South of N.S. Wales) ; *Priofinus cinereus* Salvin, Cat. Birds Brit. Mus. xxv, p. 390, 1896 ; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 81, 1907.

MATERIAL OBTAINED

No. 30. ♀ September 8, 1910. 39° 56′ S., 32° 12′ E. A. Cherry-Garrard Coll. Bill yellow ; lamelli pale horn ; legs white ; tips of claws black.

No. 32. September 9, 1910. 39° 38′ S., 34° 52′ E. A. Cherry-Garrard Coll. Bill black horn colour ; feet and legs pale flesh ; outer edge of webs darker.

No. 37. ♂ October 4, 1910. 42° 5′ S., 114° 41′ E. A. Cherry-Garrard Coll. Iris dark brown ; bill as above ; legs and feet white tinged blue.

Four days before the "Terra Nova" approached the Cape a single Brown Petrel appeared in 35° 27′ S., 0° 39′ E., for the first time on August 10 ; next day one or two were seen, and on the 13th a single example.

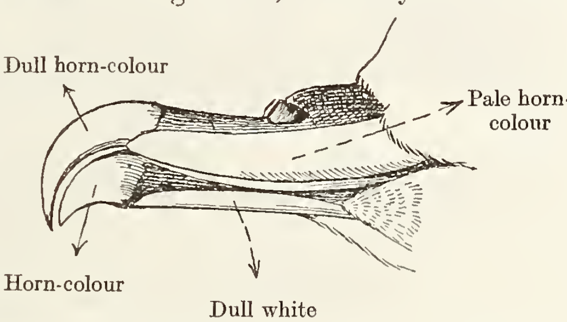

FIG. 12.—Great Grey Shearwater (*Adamastor cinerea*). Bill, to show distribution of colour, from sketch by Comd. Pennell.

On his voyage from Cape Town to New Zealand in the "Corinthic," Dr. Wilson again fell in with this bird the day after he left the Cape, and on September 13, 38° 57′ S., 28° 43′ E., he records in his notes that "A considerable number appeared to-day—thirty or more—and I saw no *Majaqueus aequinoctialis* in the afternoon when *P. cinereus* was most numerous." The next day a similar number were also seen, and after carefully watching them he writes : "These birds tread water when they come down to look at stuff that might be food, the feet drop and they paddle quickly along the surface if they decide the food is not eatable."

Between 45° 47′ S. and 77° 43′ E. on September 20, and 46° 59′ S., 100° 37′ E., on September 23, large numbers were seen, sometimes as many as a hundred or more, and after carefully watching Wilson offers a note of warning in the identification of this petrel, and says : "The back of the bird is often very easily mistaken for the back of a Sooty Albatross at a distance, when size is not judged easily."

The Brown Petrel continued to be seen daily till September 29, in 43° 48′ S., 146° 01′ E.

On the voyage to the Antarctic in December, 1910, no example of this petrel was seen, but on his way back Commander Pennell fell in with it on March 10, in 62° 00′ S., 162° 03′ E. (North of South Victoria-land), and continued to see it daily till March 25, in 50° 10′ S., 163° 14′ E., after which no more were noted.

During the surveying voyage carried out by the "Terra Nova" from July 10 to October 6, the Great Grey Shearwater was on several occasions seen between 42° 06′ S., 175° 13′ E., and 32° 55′ S., 170° 38′ E. This petrel was not met with on the second voyage to Cape Evans, but on the return trip it was noted in 61° 49′ S., 160° 04′ E., on March 20, 1912, and daily till 52° 16′ S., 167° 31′ E., was reached on the 27th of the same month.

During the third voyage to Cape Evans it first appeared on December 17, 1912, in 49° 12′ S., 178° 14′ E., and again on the 19th a little further south. Two were identified with doubt on the voyage north again on January 28, in 71° 54′ S., and 174° 58′ E., and again from February 5, 55° 17′ S., 162° 00′ E., till off the coast of New Zealand three days later.

During the voyage home from New Zealand this bird was regularly seen from March 14, 1913, 45° 17′ S., 174° 48′ E., till April 8, 55° 30′ S., 82° 54′ N., and on 17th of the same month another was noted in 44° 37′ S., 57° 35′ W. On April 5 the following entry was recorded in the Zoological log: "The Great Grey Shearwater dives into the water after the garbage thrown overboard, with its wings half outspread from a position as if it was just about to settle on the water."

16. *Thalassoeca antarctica* (The Antarctic Petrel). Plate VII and Text-fig. 13.

Procellaria antarctica Gmelin, Syst. Nat. i, pt. ii, p. 565, 1789 (in the Antarctic Circle); *Thalassœca antarctica* Salvin, Cat. Birds Brit. Mus. xxv, p. 392, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 82, 1907.

MATERIAL OBTAINED

No. 47.	63° 20′ S., 177° 22′ W.	E. A. Wilson.	Iris dark brown; bill black; latericorn yellowish; legs grey with blackish shadings on outer webs (*vide* Fig. 7.).
No. 76.	66° 38′ S., 179° 04′ W.	E. A. Wilson.	Bill black with yellowish latericorn; legs and webs flesh-grey; irish dark brown.
No. 75.	ditto.	ditto.	ditto.
No. 78.	ditto.	ditto.	ditto.

Early in the morning of December 8, 1910, in 63° 20′ S., 177° 22′ W., the first Antarctic Petrel appeared, and later on in the day it became quite abundant. Ice was then visible from the mast-head, but it was not till the following day that the ship passed a berg and ran into loose streams of ice. Dr. Wilson in his diary remarks: "We found them collected in large groups, sitting quietly together in the afternoon, once on the top of a berg and once on a large floe under the lea of a berg. I also saw three or four of them squatting in the water billing and cooing to one another."

From that date onwards Antarctic Petrels were seen daily in varying numbers, at

times as many as a hundred, till January 4, 1911, when cruising along the Ice Barrier, after which date Dr. Wilson does not again mention this species.

On January 19, Dr. Wilson records a small flock sleeping on top of an irregular berg at 6 a.m., and on the 30th he again has a note on the subject as follows: "A flock of about a hundred on a berg-top this morning at 6 a.m. (see Text-fig. 13). Another flock of a hundred or more joined the ship at 8 a.m. All were on the feed both times."

When near Cape Royds on December 25, Dr. Wilson sketched some of this species on the ice, remarking that the "Antarctic Petrel squats on the ice—or half squats, but I have never seen it quite stand up" (Plate VII, figs. 8 and 9).

FIG. 13.—Antarctic Petrel (*Thalassoeca antarctica*). Snow-topped berg with Antarctic Petrels roosting in a flock.

Commander Pennell's observations on the Antarctic Petrel commence on January 30, 1911, during the "Terra Nova's" voyage north, and he records it almost daily until 57° 23′ S., 159° 37′ E., was reached on March 19, after which no more were seen.

The following extracts from the Zoological log of the "Terra Nova" are of considerable interest:—

> *Jan.* 31, 1911.—78° 29′ S., 170° 56′ W. A small flock of about twenty flew round in the morning but disappeared almost immediately. A large flock was seen about 7 p.m. about the streams of ice off the northern point of Discovery Bay.
>
> *Feb.* 2, 1911.—76° 56′ S., 159° 01′ W. Approaching C. Colbeck, King Edward VII Land, great quantities of Antarctic Petrels, in flocks of many hundreds, flying and resting on floes in the heavy pack-ice. When settled, the white under-parts are exactly the same as the snow, only the brown upper-parts being noticeable and making the birds look very small.

Feb. 12, 1911.—72° 00′ S., 171° 56′ E. Antarctic Petrel seemed to be flying much faster than usual. At 9 a.m., as in the early morning, they were flying fast and high up, and appeared to be making for the N.W. (true). These flights of Antarctic Petrels continued all day. At 7 p.m., a fresh gale from the south set in, and blew for four days.

On the voyage from Lyttelton to Cape Adare the Antarctic Petrel was noted from December 25, 1911, 62° 10′ S., 175° 37′ W., till January 6, 1912, 74° 0′ S., 171° 18′ E., and on the return passage it was again met with from March 8, in 73° 32′ S., 174° 12′ E., till March 19, in 63° 55′ S., 158° 31′ E.

During the final voyage to Cape Evans and home this bird was again seen almost daily from December 26, 1912, when the first ice was met with in 63° 43′ S., 166° 36′ W., till January 31, 1913, in 66° 14′ S., 163° 39′ E. Six days after the pack-ice had been left.

The following entry under December 28, 1912, is worthy of note: "Many, the plumage of these birds vary considerably from a uniform dark-brown and white, to others with a dark head only, the remainder of the brown varying to a light fawn-colour. This is very noticeable when these birds are seen together on the water. Probably these are young birds, as the lines between the brown and white are not so clearly cut. They occasionally dive from the surface and stay completely submerged for several seconds."

17. *Priocella antarctica* (The Southern Fulmar).

Fulmarus antarcticus Stephens, in Shaw's Gen. Zool. xiii, p. 236, 1826 (Antarctic Ocean); *Priocella glacialoides* Salvin, Cat. Birds Brit. Mus. xxv, p. 393, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 84, 1907.

The Southern Fulmar was first recorded by Dr. Wilson on December 7, 1910, in 61° 22′ S., 179° 56′ E., when a single bird was seen, apparently just before the first ice was observed. On the two following days several more were observed, and on entering loose ice on the morning of December 9, in 66° 38′ S., 178° 47′ W., one or two were seen, but no more were met with till the ship got into the open water again in 72° 17′ S., 177° 9′ E., on December 30, when a single bird flew round the ship in the morning.

Commander Pennell on the voyage of the "Terra Nova" back to New Zealand, observed this petrel just off Cape Adare on February 20, 1911, and daily till the 24th of the same month, when the pack was entered off the North Coast of Victoria Land, 68° 50′ S., 159° 11′ E. No more were seen till February 28, in 68° 14′ S., 160° 38′ E., and from that date till March 9, 62° 51′ S., 160° 55′ E., this species was noted daily.

Under March 5, Commander Pennell remarks: "Southern Fulmar, several, moulting. Eight p.m. noticed a peculiarity of flight of Southern Fulmar, Cape Pigeon, Snowy and Antarctic Petrel: all birds seemed to twist a lot like the start of a snipe's flight, possibly due to the wind being gusty, though this was not noticeable on deck."

On the voyage south from Lyttelton to Cape Adare and back, the Southern Fulmar was first observed in 61° 01′ S., 175° 37′ W., on December 25, 1911, and continued to

be noted till the 27th no more were seen till 70° 02′ S., 175° 31′ E., was reached six days later, while on March 8, 1912, three more were seen in 73° 32′ S., 174° 12′ E., and from that date they were seen almost daily till March 19, 63° 55′ S., 158° 31′ E.

In the third voyage south the officers of the "Terra Nova" first observed the Southern Fulmar on December 26, 1912, in 65° 53′ S., 166° 03′ W., which continued with the ship for two days to 69° 28′ S., 166° 17′ W. No more were seen till the return, when the species was again met with on January 30 and February 1, 1913, between 68° 18′ S., 168° 47′ E., and 64° 04′ S., 158° 52′ E.

During the final voyage home from New Zealand a single example of this species was seen on April 9, 1913, in 55° 29′ S., 78° 41′ W., and quite a number were noted the next few days, but after April 13, 56° 03′ S., 63° 46′ W., no birds were observed.

18. *Procellaria aequinoctialis* (The Cape Hen). Text-figs. 14 and 15.

Procellaria aequinoctialis Linn. Syst. Nat. ed. x, p. 132, 1758 (Cape Seas); *Majaqueus aequinoctialis* Salvin, Cat. Birds Brit. Mus. vol. xxv, p. 395, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 86, 1907.

The White-chinned Petrel or Cape Hen was seen by Dr. Wilson on August 1, 1910, in 26° 23′ S., 22° 43′ W., and in his diary he notes: "One appeared in the water and kept some distance off, but the identification was reliable." Next day two were seen and on the following several; after that it was noted in varying numbers till August 14 in 35° 46′ S., 3° 52′ E.

Fig. 14.—Cape Hen (*Procellaria aequinoctialis*). Submerging.

As he left Cape Town in R.M.S. "Corinthic" on September 11, Dr. Wilson records seeing "Any number" of this bird, and on the 12th, in 36° 26′ S., 22° 47′ E., he writes in his diary: "Any number present. When feeding they go completely under water with their feet and wings outspread and come up again with the wings still spread exactly as do the Shearwaters." He illustrated the above note with the accompanying sketches (Text-figs. 14 and 15).

This petrel continued to be met with daily in fluctuating numbers of from one or two to as many as seven individuals till September 20, in 45° 47′ S., 77° 43′ E. Commander Pennell saw a Cape Hen, on September 10, 1910, in 38° 58′ S., 35° 24′ E., "without white chin, came in very close; bill lighter yellow than usual," which points very much to the bird being *M. parkinsoni*, but in his later records, March 8, 1911, 64° 23′ S., 161° 39′ E., and December 16, 1912, 47° 06′ S., 176° 11′ E., he makes no mention of the absence of the white, so possibly these birds were *P. a. aequinoctialis* or *steadi*.

Fig. 15.—Cape Hen (*Procellaria aequinoctialis*). Coming to surface again.

On the voyage home in 1913 the White-chinned Petrel was seen daily from April 8, in 55° 30′ S., 82° 54′ W., to April 17, in 44° 37′ S., 57° 35′ W.

Some birds were apparently not quite typical *P. a. aequinoctialis*, as there is an entry in the zoological log that: "Two or three seen" on April 9 "were totally black, with a light-coloured bill and apparently some white feathers on the face, *i.e.* just round the bill"; and again on April 13 the bird seen was said to have: "white chin was distinct, but no white on head in any we have seen this cruise."

19. *Pterodroma lessonii* (Lesson's Petrel). Plate V.

Procellaria lessonii Garnot, Ann. Sci. Nat. Paris, vii, p. 54, 1826; *Oestrelata lessoni* Salvin, Cat. Birds Brit. Mus. xxv, p. 401, 1896; Wilson, Nat. Ant. Exped. N. H. ii, Aves, p. 87, 1907.

When proceeding from Cape Town to Melbourne, in R.M.S. "Corinthic," Dr. Wilson first noted the petrel on September 25, 1911, in 46° 30′ S., 116° 07′ E., South of King George's Sound, S. Australia. He records the following note in his diary: "*Oestrelata lessoni*, about four, sometimes quite near the ship, heads almost pure white and very pronounced black mark over the eye and wings black on the under side" (*vide* Plate V, fig. 204). Two individuals were seen on the following day and one on the 27th, in 45° 18′ S., 131° 27′ E.

After leaving for the south Dr. Wilson observed a single bird on December 1 off Campbell Island, and three days later he saw what he thought was another, but it too far off to identify for certain.

Commander Pennell and the officers of the "Terra Nova," returning in 1911 to New Zealand, noted this bird daily between March 10, 62° 00′ S., 162° 00′ E., and March 25, 5° 10′ S., 163° 14′ E.

Under the date of March 17 the following entry was made in the Zoological log: "There can be no doubt as to the identity of this bird, as during the time, under sail, it has frequently come fairly close. The whitish head and tail and the very distinct black-V made by the wings distinguishing it at a long distance. It would appear to be rather a solitary bird, as we have not seen more than a couple at a time, and generally only single birds. It also, as a rule, keeps rather far from the ship."

After leaving Cape Evans on the return voyage in 1912, Lesson's Petrel was again observed from March 12, 69° 23′ S., 177° 52′ E., to March 27, 52° 16′ S., 167° 31′ E., and during the third voyage there are records for it on December 16, 1912, 47° 06′ S., 176° 11′ E., to December 20, 53° 47′ S., 176° 45′ W., and later, between February 3, 1913, 59° 29′ S., 157° 33′ E., and February 5, 55° 17′ S., and 162° E.

During the voyage home from New Zealand this petrel was seen almost daily from March 15, 1913, 46° 58′ S., 176° 01° E., to April 5, 55° 03′ S., 100° 37′ W. The following observation was entered in the zoological log for March 20: "These birds always keep far away from the ship, and are hardly ever seen coming to the slops, etc., thrown overboard. It is hard to say why they find a vessel attractive."

On Plate V are reproduced six studies of this petrel made by Dr. Wilson on the "Discovery" in 1901 and 1904, and during his passage from the Cape to New Zealand on R.M.S. "Corinthic," in September, 1901.

20. *Pterodroma arminjoniana* (Arminjon's Fulmar). Plates III, fig. 2, IV, VI, figs. 2 and 2*a*, and Text-fig. 16.

Oestrelata arminjoniana Gigl. et Salvad. Atti Soc. Ital. Sci. Nat. xi, p. 452, 1868 (28° 56′ S., 36° 24′ W.); Salvin, Cat. Birds Brit. Mus. xxv, p. 418, 1896; Sharpe, "Birds of South Trinidad," *Ibis*, 1904, p. 215; *Oestrelata trinitatis* Salvin, Cat. Birds Brit. Mus. xxv, p. 413, 1896; Sharpe, "Birds of South Trinidad," *Ibis*, 1904, p. 215; *Oestrelata wilsoni* Sharpe, Bull. Brit. Orn. Club, xii, p. 49, 1902; "Birds of South Trinidad," *Ibis*, 1904, p. 216.

MATERIAL OBTAINED

No. 1.	♀	28.vii.1910.	S. Trinidad.	E. A. Wilson.	Bill black, iris dark brown; legs white flesh-tinted; feet black and whitish. Caught by hand on nesting ledge close to black specimen.
No. 2.	♂	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs white, flesh tinted; feet white and black.
No. 4.	♂	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs black but with white spots on back of tarsus; feet black.
No. 5.	♀	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs white, flesh-tinted; feet white and black.
No. 6.	♂	ditto.	ditto.	ditto.	ditto.
No. 8.	♀	ditto.	ditto.	ditto.	ditto.
No. 9.	♀	ditto.	ditto.	ditto.	ditto.
No. 10.	♀	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs black (wholly); feet black (wholly); webs black.
No. 11.	♀	ditto.	ditto.	ditto.	ditto.
No. 12.	♀	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs and feet not wholly black.
No. 15.	♂	ditto.	ditto.	ditto.	Bill black; iris dark brown; legs white, flesh-tinted; feet white and black.
No. 16.	♂	ditto.	ditto.	ditto.	ditto.
No. 24.	♀	ditto.	ditto.	ditto.	ditto.

This petrel was first described by Giglioli and Salvadori from specimens taken by the former in January, 1868, while becalmed in the "Magenta" eight miles from the island of South Trinidad (*Ibis*, 1869, pp. 62–63).

On the same day several specimens of a uniformly dark petrel of a similar size were procured "around Trinidad Island," where it was found to be "pretty abundant," and was subsequently described by the same authors as *Oestrelata trinitatis* (*loc. cit.* p. 65).

In 1902 (Bull. B.O.C. xii, p. 49), on the receipt of the birds collected during the outward voyage of the "Discovery," Bowdler Sharpe described what is now generally regarded as a dark colour-phase of *P. arminjoniana*, under the name of *Oestrelata wilsoni* based on further specimens procured by Dr. Wilson in September, 1901. Nicoll in 1905 visited the island on Lord Crawford's yacht "Valhalla"; he recognised two species in *O. arminjoniana* and *O. trinitatis*, but doubted if *O. wilsoni* was distinct from the former. In April, 1914, Murphy (*Auk*, xxxi, p. 12, pl. 2) visited the island but was unable to land. He shot a bird which probably will be universally regarded by ornithologists as a colour-freak and described it as *Oestrelata chionophara*. Various views have since been held and expressed as to whether these several forms represent one, two or more species. For example, Dr. Bowdler Sharpe recognised as distinct species *Oestrelata trinitatis*, *Oestrelata arminjoniana*, and *Oestrelata wilsoni*, the last with two colour-phases, a grey and a white. Salvin, Cat. of Birds Brit. Mus. thought *O. trinitatis* was probably a dark form of *O. arminjoniana*. Ogilvie-Grant, in MSS., regarded *O. wilsoni* as a synonym of *O. arminjoniana* and thought that the latter had two colour phases, a white-breasted and a dark-grey-breasted phase. He recognised two species *O. arminjoniana* and *O. trinitatis*. Murphy (*Auk*, xxxii, 1915, p. 342) recognised three species, *O. arminjoniana, trinitatis*, and *chionophara*, although prepared to admit that future study might yet demonstrate that *O. arminjoniana* and *trinitatis* are one species and that *O. chionophara* might be a freak.

FIG. 16.—Arminjon's Fulmar (*Pterodroma arminjoniana*). In flight.

Wilson, when he landed from the "Terra Nova," was convinced that *O. arminjoniana* and *O. trinitatis* were two forms of one species.

As regards our own conclusions, based on the examination of thirty-four examples, we are of the opinion that the mere examination of the skins available for the purpose, although possibly fruitful in giving one certain indications of the truth, is not likely to lead to any definite or satisfactory solution of the problem. To arrive at this an intensive study of the birds on the island itself seems essential, or what would probably amount to the same thing, an intensive field study of other petrels having similar colour-phases. In this connection one of the problems to be solved is the question of what part, if any, geographical or physiological isolation is given a chance to play on a small island like South Trinidad. As regards geographical isolation it seems plain that the island represents the permanent home at all times of the year of all three forms of the

petrel under discussion; for Wilson in July and September, Giglioli and Nicoll in January, Murphy in April, found all the three phases present together. As regards physiological isolation, it is equally plain from the published accounts, that there are at least two nesting seasons, viz. in January and September, eggs having been taken at both these seasons, while Wilson in his "Terra Nova" diary records finding young birds *in down* in July. Such an isolation in point of time would of course have just as much influence in regard to the segregation of characters as geographical isolation of the most pronounced kind. Thus it is possible to conceive that in the January broods any one factor or tendency such as the factor for excess of pigment might have become dominant, while in the September brood an opposite condition might obtain.

That there is some evidence pointing to segregation seems evident from what Wilson says in his last diary ("Terra Nova"), *e.g.* "We found these Petrels (*O. trinitatis* and *O. arminjoniana*) flying around and along cliff ledges and settling into the crevices, black-breasted and white-breasted sometimes together in one crevice. We climbed to these and caught the birds together on the same ledge—but there were no eggs. We had found these eggs on the previous 'Discovery' visit in September, but now, in *July* [italics ours], there were no eggs. There were, however, quite a number of young birds, *O. trinitatis* or *O. arminjoniana* in down, an ashy-grey down, which showed on the breast that white feathers were to come. [These must have been the light phase known as *P. arminjoniana.*] *We found no young with black feathers coming on the breast.* [*P. trinitatis.*] None of the young were recently hatched, all were a fair size." This may or may not mean that there were actually no young birds of the form called *P. trinitatis* on the island at the time of Wilson's visit; for it must be noted that Wilson goes on to say that this form was rarer than the light-breasted bird known as *P. arminjoniana* in the proportion of "one to fifteen or twenty or more"; so that it may have been pure chance that Wilson did not come across any young black forms. However, Nicoll when he landed from the "Valhalla" in *January* (*Ibis*, 1906, p. 672) noted that *P. trinitatis* "*at the time of our visit had large downy young.*" He also remarks on the relative rareness of this form, and that it was only met with at some distance up the hill-side. These facts therefore suggest that the nesting seasons of these light and dark forms do not synchronise.

In a study of the birds of the Kermadec Islands, New Zealand, Iredale (*Ibis*, 1914, pp. 423–436), in the case of *O. neglecta* of Schlegel, has given his reasons for thinking that in spite of the remarkable amount of diversity in the forms met with, only one species of *Oestrelata* exists on that group. It is interesting to note that although Iredale made an actual inventory of the individual petrels referable to *O. neglecta*, he found no evidence of segregation in respect of colour-pattern. Thus out of 264 birds examined he notes that "In only two cases were a light and a very dark one paired, and in no case were two very light birds observed mated, and in only one case were two black birds together." Hutton also noted the coloration of sitting birds on these islands and found that out of the first eighteen examined four were dark, four were light, and

MEASUREMENTS OF *PTERODROMA ARMINJONIANA.*

Number and Sex.	Date.	Locality.		Legs.	Feet.	Culmen.	Tarsus.	Wing.
			WHITE-BELLIED FORM					
1 ♀	28.vii.1910	South Trinidad Is. E. A. Wilson	Caught by hand on nesting ledge close to a black specimen.	White—flesh tinted	Black and whitish	30	39	290
2 ♂	"	" " "		" "	White and black	30	36	288
5 ♀	"	" " "		" "	" "	28	38	285
6 ♂	"	" " "		" "	" "	29	38	297
7 ♂	"	" " "		" "	" "	30	36	290
8 ♀	"	" " "		" "	" "	28	37	287
9 ♀	"	" " "		" "	" "	28	36	300
14 ♂	"	" " "		" "	" "	32	37	292
15 ♂	"	" " "		" "	" "	30	37	284
16 ♂	"	" " "		" "	" "	30	37	290
24 ♀	"	" " "		" "	" "	29	36	292
7 ♂	13.ix.1901	" " "	Caught sitting on an egg	Pink	Pink and black	30	36	299
♀	"	" " "	Type of *O. wilsoni* Sharpe	"	" "	28	36	290
101 ♀	3.i.1906	South Trinidad Is. M. J. Nicoll		—	—	28	36	284
112 ♂	"	" " "		—	—	30	37	290
113 ♂	"	" " "		—	—	30	37	296
251 ♂	31.xii.1905	21° 51′ N., 43° 35′ W. P. R. Lowe		Pale opalescent blue	Web, ant. ⅔ dark sepia brown; post. ⅓ like tarsus	30	37	293
			GREY-BELLIED BIRDS					
♀	13.ix.1901	S. Trinidad. E. A. Wilson		Pink	Pink and black	29	36	280
3 ♂	"	" "		"	" "	30	38	298
105 ♂	3.i.1906	S. Trinidad. M. J. Nicoll		Flesh colour	Basal half of toes flesh-colour, rest of toes and webs of outer side of outer toe black.	29	35	280
107 ♀	"	" "		" "	"	27	38	289
111 ♂	"	" "		Dark brown	Basal half of toes dark brown, webs and rest of toes black.	29	37	280
114 ♂	"	" "		Light brown	Base of toes light brown, rest of toes, webs, and outer side of outer toe black.	29	35	285
109 ♀	"	" "		Brownish flesh	Basal half of two inner toes brownish flesh-colour, outer toe and webs black.	27	36	281
			DARK PHASE					
1 ♂	13.ix.1901	S. Trinidad. E. A. Wilson	Caught sitting on eggs	Pink	Pink and black	28	37	278
36 ♂	"	" "		Black	Black	29	37	287
4 ♂	28.vii.1910	" "		Black with white spots on back of tarsus	Black	29	38	292
10 ♀	"	" "		Black (wholly)	Webs black	30	37	280
11 ♀	"	" "		"	" "	28	38	281
12 ♀	"	" "		Not wholly black, *vide* Plate	upper parts paler. VI. fig. 2*a*.	28	37	288
84 ♀	5.i.1906	Martin Vas. M. J. Nicoll		Black	Black	30	37	289
110 ♂	3.i.1906	S. Trinidad. M. J. Nicoll		Black	Black	30	36	—
99 ♂	3.i.1906	" "		Black	Black	30	36	—
108 ♀	3.i.1906	" "		Tarsi light brown	Base of toes light brown, rest of toes and webs black.	30	39	288

ten were medium. As far as conclusions derived from a study of the fine series of skins of *Pterodroma arminjoniana* preserved in the British Museum are worth anything at all, we ourselves found that the skins could be arranged in the following categories :—

(*a*) A light phase with white and black feet and legs.
(*b*) A dark phase with all black feet and legs.
(*c*) An intermediate phase with pink and black feet and legs.

We can find no convincing evidence justifying the assumption that these phases have specific value, but we are of the opinion that the part played by physiological isolation, due to differences in the time of nesting, as it might affect various groups of these petrels on the island, might be studied with profit.

21. *Pterodroma mollis mollis* (Soft-plumaged Petrel). Plate VI, figs. 1, 1*a*.

Procellaria mollis Gould, Ann. Mag. Nat. Hist. vol. xiii, p. 363, 1844 (South Atlantic Ocean, 29° 45′ S., 15° 3′ W.) ; *Oestrelata mollis* Salvin, Cat. Birds Brit. Mus. vol. xxv, p. 406, 1896.

MATERIAL OBTAINED

No. 17. ♀ 3.viii.1910. At sea N.W. of Tristan da Cunha, 30° 18′ S., 19° 28′ W. Bill black ; iris dark brown ; legs flesh tint ; feet flesh tint and black.

The Soft-plumaged Petrel was never seen during the voyage of the " Discovery," but in the present expedition this species was not unfrequently noted between South Trinidad and a little S.E. of the Cape.

On July 30, 1910, in 24° 42′ S., 29° 49′ W., S.E. of South Trinidad, Dr. Wilson notes :—" Two seen : distinctly smaller than *P. arminjoniana*," and next day about twenty were noted—" flying about the wake all day like Shearwaters." Commander Pennell writes : " When at its highest flight and about to turn down, its wings are held in a manner similar to a Sandpiper." Before No. 71 was skinned Dr. Wilson made careful paintings of the head and feet, which are reproduced on Plate VI, figs. 1 and 1*a*.

As the " Terra Nova " was making for Cape Town a single example was observed in 35° 17′ S., 13° 38′ E.

22. *Pterodroma macroptera macroptera* (Grey-faced Petrel). Text-fig. 17.

Procellaria macroptera Smith, Ill. Zool. S. Africa, pl. 52, 1840 (Cape Seas) ; *Oestrelata macroptera* Salvin, Cat. Birds Brit. Mus. vol. xxv, p. 399, 1896.

When north of Gough Island in 30° 56′ S., 16° 48′ W., on August 4, 1910, Dr. Wilson writes under this species :—" First seen to-day ; one only." Next day he writes :— " One or two, black or brownish-black all over, above and below—bill, feet and legs. The only part which is a little lighter is the face, which is grey. The wings are long,

pointed, and rather bent or hooky in flight. [Text-fig. 17.] The bird is much smaller than *Májaqueus aequinoctialis* but a trifle larger than *Oestrelata mollis.*" To this note Lieut.-Commander Pennell adds :—" Absolutely black or very dark brown all over, including the underparts of the wings, and with the exception of the front of the head, which is grey. Bill black, a shade larger than *O. mollis.*"

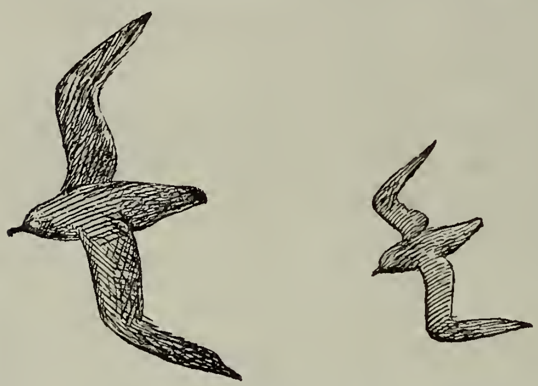

Fig. 17.—Grey-faced Petrel (*Pterodroma macroptera macroptera*). Studies in flight.

From the above date the Great-winged Petrel is entered daily in Dr. Wilson's diary till August 14, when the "Terra Nova" was just off Cape Town. He again notes this petrel two days out from Cape Town in 38° 57′ S., 28° 43′ E., on September 13, as follows : "A smallish, wholly black, long and narrow pointed-winged Petrel was with us all day, round and abeam of the ship, not aft. Also on the following day, in 40° 58′ S., 34° 41′ E. : "One or two. One was astern to-day with a black *Macronectes*, and a *Majaqueus.* The three sizes were very distinct."

On September 6, 1910, Commander Pennell mentions : "Two or three seen, have only seen single birds before, since leaving the Cape." And while doing survey work on the "Terra Nova," in the winter of 1911 (July–September), off Three Kings Island, New Zealand, there is frequent mention of this petrel in the zoological log. There are also several other entries seen at different times in 1912 as far south as 59° 28′ S., 169° 33′ W., on December 24, and on January 29, 1913, in 69° 56′ S., 170° 52′ E.

23. *Pagodroma nivea* (Snowy Petrel). Text-figs. 18 and 19.

Procellaria nivea Forster, "Voy. Round World," i, pp. 96–98, 1777 (51° 50′ S., 21° 3′ E.) ; *Procellaria candida* Peale, U.S. Explor. Exped. viii, p. 295, 1848 (64° S., 104° W.) ; *Pagodroma nivea* (Gm.) Salvin, Cat. Birds Brit. Mus. xxv, p. 419, 1896 ; Wilson, Aves, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 88, 1907 ; *Pagodroma confusa* Mathews, "B. of Aust." ii, p. 177, 1912 (Cape Adare).

MATERIAL OBTAINED

No. 16.	♂ 14.xii.1910.	67° 28′ S., 177° 58′ W.	E. A. Wilson.	"Shot in pack."
No. 48.	♂ 15.xii.1910.	67° 28′ S., 177° 58′ W.	E. A. Wilson.	Weight 9 ozs.
No. 79.	10.xii.1910.	66° 38′ S., 179° 04′ W.	E. A. Wilson.	Shot in pack.

Bill black, iris dark brown, legs and webs blackish-grey.

The first Snowy Petrel met with on the voyage south was on December 8, 1910, in 63° 20′ S., 177° 22′ W. ; the following day a considerable number were seen on the 10th in 66° 38′ S., 178° 47′ W. "Five or six were round the ship all day. Those we shot exhibited the differences in size, weight and bill very well indeed ; some had the

bill large and thick, in others it was small and finely made." This petrel continued to be seen daily, and up till January 4, 1911, five miles East of Cape Crozier, we find the entries, such as "a few," "several all day," "a small flock," in Dr. Wilson's notebook.

In the "Terra Nova's" zoological log book there are similar entries to the

Fig. 18.—Snowy Petrel (*Pagodroma nivea*). Feeding among the "brash" ice.

above till 64° 23″ S., 161° 39′ E., was reached on March 8, after which none was recorded. On this voyage several interesting observations were made which are worth quoting :—

Feb. 2, 1911.—Near Cape Colbeck. A Snowy Petrel settled on the water, then dipped completely under for a quarter of a minute with almost closed wings.

Feb. 13, 1911.—50 miles N.W. of Cape Adare. One settled on the water to pick up something thrown from the ship. It settled for about two minutes, but kept its wings extended above its back the whole time until it rose again.

Feb. 28, 1911.—68° 14′ S., 160° 38′ E. Snowy Petrels settling on the ice in small flocks, walking in a very ungainly waddling fashion, and shuffling about a lot before they nestled down and were still.

March 4, 1911.—67° 11′ S., 160° 47′ E. In the afternoon two Snowy Petrels came on board, one being so gorged that it could hardly fly. On being picked up it vomited *Euphausia* and four large eggs. Some flying about 200 feet above the ship were twittering almost exactly like Linnets, etc. They twitter when they fly in flocks fairly high up, in winter : this is the first time I have heard this note.

Fig. 19.—Snowy Petrel (*Pagodroma nivea*). Studies in flight.

When the "Terra Nova" went south in December, 1911, Snowy Petrels were

MEASUREMENTS OF *PAGODROMA NIVEA*.

Reg. No.	Sex	Date.	Locality.	Collected by.	Length of Culmen.*	Depth of Culmen.†	Wing.	Tarsus.	Notes.
Tring Museum ..		1.i.1899	"Cape Adare"	*ex* Mathews Collection, type of *P. confusa*.	26	13	297	39	
1901.i.7.36	♂	,,	63° 27′ S., 160° 6′ E.	"Southern Cross" Exped. N. Hanson [C.]	26	13·5	302	40	
Tring Museum ..	♂	31.xii.1898	62° 52′ S., 159° 25′ E.	,, ,, ,,	26	14	293	40	
1916.6.20.50	♂	14.xii.1910	67° 28′ S., 177° 58′ W.	"Terra Nova" Exped. E. A. Wilson [C.]	26	13	297	40	
Tring Museum ..	—	—	Cape Adare, 71° 18′ S., 170° 45′ E.	.. ..	26	12·5	290	38	
1842.12.16.68	—	—	Ross Sea	"Erebus" and "Terror" Exped. ..	25	12·5	290	38	
1905.12.30.362 ..	♀	28.xi.1902	68° S., 175° 26′ E.	"Morning" Relief Exped. A. G. Davidson [C.]	23	11	300	38	
1891.2.15.2	—	31.xii.1840	Pack-ice, Victoria Land, 66° S., 171° 50′ E.	"Erebus" and "Terror" Exped. R. McCormick [C.]	23	13	290+	39	
1905.12.30.357 ..	♀	14.ii.1902	Great Ice Barrier, Ross Sea ..	"Discovery" Exped. E. A. Wilson [C.]	23	12	293	37	
1905.12.30.286 ..	♀	11.i.1902	Off Cape Adare, 71° 18′ S., 170° 45′ E.	,, ,, ,,	23	12	309	40	
1844.1.18.32	♀	22.ii.1842	76° 42′ S., 0° 50′ W. [77° S.] ..	"Erebus" and "Terror" Exped. ...	23	10	267	34	
Tring Museum ..	—	i.1842	Between 66° 32′ S., 169° 45′ E. and 77° 06′ S., 180° 06′ E.	,, ,, ,, J. D. Hooker [C.]	22	11	268	34	
,, ,, ...	♀	12.i.1899	65° 3′ S., 161° 42′ E.	"Southern Cross" Exped. Fig. by Mathews	22	12	302	38	
Royal Scottish Museum	♀	26.ii.1904	Cape North, 70° 31′ S., 165° 28′ E.	"Discovery" Exped. E. A. Wilson [C.]	23	12	252	38·5	Moulting.
1905.12.30.356 ..	♂	11.i.1902	Off Cape Adare, 71° 18′ S., 169° 45′ E.	,, ,, ,,	21·5	10·5	267	33	
1901.1.7.37	♀	1.i.1899	63° 27′ S., 160° 6′ E.	"Southern Cross" Exped. N. Hanson [C.]	21	12·5	298	40	
1905.12.30.363.. ..	♀	28.xi.1902	68° S., 175° E.	"Morning" Relief Exped. A. G. Davidson [C.]	21	11	263	34	
1905.12.30.358.. ..	♂	4.xi.1902	Great Ice Barrier, Ross Sea ..	"Discovery" Exped. E. A. Wilson [C.]	21	11	265	33	
Tring Museum ..		31.i.1902	,, ,, ..	,, ,, ,,	21	11	269	35	
,, ,, ..	—	13.xii.1898	62° 52′ S., 159° 25′ E.	"Southern Cross" Exped. Fig. by Mathews.	21	11	268	34	
1842.6.11.6	—	1841	Ross Sea	"Erebus" and "Terror" Exped. Lt. A. Smith, R.N.	21	11	260	32	
1901.1.7.38	♀	28.iv.1899	Cape Adare, 71° 18′ S., 170° 45′ E.	"Southern Cross" Exped. H. Evans [C.]	20	9	251	32	Grey outer web to first primary.
1901.1.7.39	♀	30.iv.1899	,, ,, ,,	,, ,, ,,	20	10	254	34·5	Ditto
1844.1.18.33	—	23.ii.1842	77° 49′, 162° 35′ W. [78° S.] ..	"Erebus" and "Terror" Exped. ..	20	10	265	34	
1891.2.15.3	—	18.ii.1841	Victoria Land, 76° 06′ E., 166° 11′ E.	"Erebus" and "Terror" Exped. R. McCormick [C.]	20	—	233+	34	
1891.6.15.20	–	17.ii.1841	Nearest the Magnetic Pole, 76° 35′ S., 165° 21′ E.	,, ,, ,,	20	10	267	34	
1905.12.30.365 ..		—	Pack-ice, Mouth of Ross Sea ..	"Morning" Relief Exped. A. G. Davidson [C.]	20	10	264	34	Grey outer web to first primary.
1906.6.20.49	♂	15.xii.1910	67° 28′ S., 177° 58′ W.	"Terra Nova" Exped. E. A. Wilson [C.]	20	10	269	35	
1916.12.30.354.. ..	♀	5.i.1902	68° S., 176° E.	"Discovery" Exped. ,,	20	10	261	34	
Tring Museum.. ..	♂	13.xii.1899	Cape Adare, 71° 18′ S., 170° 45′ E.	,, H. B. Evans [C.]	20	10	258	31	
1842.12.16.97	♀	1841	Ross Sea	"Erebus" and "Terror" Exped. ..	20	—	250+	32	
1842.12.16.93	♂	1841	,, ...	,, ,, ,, ..	20	—	262	34	
1916.6.20.51	—	10.xii.1910	66° 38′ S., 177° 04′ W.	"Terra Nova" Exped. E. A. Wilson [C.]	19	9·5	252	33	Grey outer web to first primary.
Liverpool Museum ..	♂	vii.1844	Victoria Land	.. ..	19	10	254	34	
1842.12.16.65	—	1841	Ross Sea	"Erebus" and "Terror" Exped. ..	19	10·5	251	32	
1905.12.30.352 ..	♀	11.i.1902	Cape Adare, 71° 18′ S., 170° 9′ E.	"Discovery" Exped. E. A. Wilson [C.]	18	10	254	33	

* Measured from feathers on forehead to tip. † Measured at greatest depth behind the narial tubes.

MEASUREMENTS OF *PAGODROMA NIVEA*.

Reg. No.	Sex.	Date.	Locality.	Collected by.	Length of Culmen.*	Depth of Culmen.†	Wing.	Tarsus.	Notes.
United States National Museum.			64° S., 104° W.	United States Exploration Exped. ..	21	8	260	33	Co. type of Peal's *candida*. Kindly lent by the U.S. National Museum.
1880.11.18.637 ..	♀	14.ii.1874	65° 42′ S., 79° 49′ E.	"Challenger" Exped.	19	—	246	32	
	♀	14.ii.1874	65° 42′ S., 79° 49′ E.	,, ,, ...	19	9	—	31	
1891.2.15.1	♂	2.i.1843	64° 14′ S., 55° 54′ W. Louis Philippe Land.	"Erebus" and "Terror" Exped. R. McCormick [C.]	22·5	—	275+	35	
Paris Museum	♂	2.viii.1909	Peterman Is., Graham Land ..	"Pourquoi Pas ?" Exped. L. Gain [C.]	24	13	300	—	Measured by M. J. Berlioz.
,, ,, ...	♂	15.viii.1909	,, ,, ..	,, ,, ,,	22	12	290	37	,, ,,
,, ,, ...	♂	16.vi.1909	,, ,, ..	,, ,, ,,	22·9	11·9	289	37	,, ,,
,, ,, ...	♂	17.vi.1909	,, ,, ..	,, ,, ,,	22·9	11·9	270	34	,, ,,
,, ,, ...	♂	3.viii.1909	,, ..	,, ,, ,,	21·9	11·9	269	32	,, ,,
,, ,, ...	♂	14.vi.1909	,, ,, ..	,, ,, ,,	21	11	269	32	,, ,,
,, ,, ...	♂	6.vii.1909	,, ,, ..	,, ,, ,,	21	10	in moult	30	,, ,,
,, ,, ...	♂	6.v.1909	,, ,, ..	,, ,, ,,	21	11	278	35	,, ,,
,, ,, ...	♂	16.vi.1909	,, ,, ..	,, ,, ,,	20	10	262	33	,, ,,
,, ,, ...	♂	16.vi.1909	,, ,, ..	,, ,, ,,	20	10	269	32	,, ,,
,, ,, ...	♂	9.iv.1909	,, ,, ..	,, ,, ,,	20	10	270	35	,, ,,
,, ,, ...	♂	15.vi.1909	,, ,, ..	,, ,, ,,	18·9	10	299	30	,, ,,
,, ,, ...	♂	7.vi.1909	,, ,, ..	,, ,, ,,	18·9	10	252	30	,, ,,
,, ,, ...	♀	14.vi.1909	,, ,, ..	,, ,, ,,	18·9	10	260	30	,, ,,
Royal Scottish Museum	—	28.ii.1904	66° 21′ S., 28° 30′ W. Weddell Sea	"Scotia" Exped.	21	11	255	34	Grey outer web to first primary.
,, ,, ,,	—	28.ii.1904	66° 21′ S., 28° 30′ W. ,, ,,	,, ,, ...	20	—	245	32	
,, ,, ,,	—	3.iii.1904	72° 18′ S., 17° 59′ W.	,, ,, ...	18·5	—	—	34	Head and legs only.
	—	14.iii.1904	73° 11′ S., 23° 53′ W.	.. ..	18·5	—	—	33	,, ,,
American Museum ..	♂	19.vii.1914	South Georgia	.. ..	19·8	9·2‡	263	—	Measured by R. C. Murphy.
,, ,, ..	♂	1912	,, ,, ...	.. ..	19·7	9	245	—	Worn.
1922.12.6.78	♀	9.iii.1922	,, ,, 56° 75′ S., 38° 11′ W.	"Quest" Exped. G. H. Wilkens [C.]	19·5	9	240	34	
1904.3.8.28	♀	14.xi.1913	,, ,, ...	P. Stammwitz	18	9·5	243	31	
Royal Scottish Museum	♂	2.ii.1903	60° 38′ S., 43° 40′ W.	"Scotia" Exped.	21·5	12	270	34·5	
,, ,, ,,	♂	15.v.1903	South Orkneys	,, ,, ...	21	12	282	36	
,, ,, ,,	♀	2.ii.1903	60° 38′ S., 43° 40′ W.	,, ,, ...	21	10·5	263	34	
,, ,, ,,	—		No locality	,, ,, ...	22	12	—	36	
American Museum ..	♂	27.i.1921	Wilhelmina Bay, S. Shetlands ..	.. ..	21	10·8	274	—	Measured by R. C. Murphy.‡
,, ,, ..	♀	27.i.1921	,, ,, ..	.. ..	21	11·5	—	270	
1851.1.29.8	—	—	Falkland Islands	H.M.S. "Rattlesnake." J. McGillivray.	21	10	34·5	272	

* Measured from feathers on forehead to tip. † Measured at greatest depth behind the narial tubes.
‡ Measured perpendicularly from the base of the culmen behind the narial tubes.

again first met with in about the same latitude as the previous year, and continued to be seen almost daily throughout the voyage to Cape Evans and back, the last observed being in 65° 33′ S., 161° 37′ E., on March 17. Under the date of January 2, 1912, 70° 02′ S., 175° 31′ E., the following entry appears in the zoological log :—" Saw several Snowy Petrels, settled on the water with their wings stretched out flat on the surface, splashing and fluttering like sparrows in the dust." Again on February 16 in McMurdo Sound between Butter Point and Cape Evans :—" Large flocks of a dozen or more birds together. These birds kept higher than usual, flying about the same height as our mast-heads. Odd petrels have been seen from time to time during the last week."

During the third voyage south this beautiful petrel was not met with till 69° 28′ S., 166° 17′ W., on December 29, as the ship entered loose pack-ice, and the whole time the " Terra Nova " was south of that latitude this bird was in evidence, but after 69° 56′ S., 174° 52′ E., was reached on January 29 it was not seen again.

Systematic Notes.—Both Dr. Sharpe and Dr. E. A. Wilson have drawn special attention to the great variations in size of this petrel, but from the material at their disposal they were not able to prove that more than one species or sub-species existed. The birds collected during the voyages of the " Terra Nova " do not help in the solution of the problem, and till specimens are collected on the different breeding grounds, it is unlikely that any satisfactory division of this petrel can be made.

We know that the Snowy Petrel breeds at Cape Adare, where Borchgrevink found it nesting in November, 1899, and it is also known to breed in the South Shetlands, South Georgia, and South Orkneys, from November to the end of December or early in January.

Dr. Wilson's statement that McCormick of the " Erebus " and Webster of H.M.S. " Chanticleer " have described the nesting of this petrel is an error. McCormick, it is true, saw numbers of birds on Louis Philippe Land on January 2, 1843, but he was unable to land. Sir James Ross, however, obtained some eggs on Cockburn Island on January 6, 1843. Webster, the surgeon of H.M.S. " Chanticleer," mentions that a number of petrels, etc., were breeding on Deception Islands in January, 1892, but gives no description of the nesting habits nor does he actually mention whether eggs were collected.

Mathews has divided the Snowy Petrel into two species and one sub-species, as follows :—

Pagodroma nivea nivea Forst. Type locality 52° S., 20° E. Range south of South America and South Seas.

Pagodroma nivea candida Peale. Type locality 64° S., 104° W. Range South Pole, Cape Adare to Australia.

Pagodroma confusa Math. Type locality Cape Adare, Victoria Land.

In the " Birds of Australia " Mathews separated the large-billed birds on account of their size. " Upon sorting them," he writes, " into groups according to localities, it

was apparent that some other conclusions must be arrived at, as large and small birds were present from the same place, but it seemed that the large ones were constantly larger, while the small were as regularly smaller, and that no intermediates were extant."

"Careful measurements confirm this; nine birds giving: Bill 20–22 by 9·5–10·5; wing 251–263; tarsus 30–32; middle toe 33–35; middle claw 10–11 mm.; while four others gave: Bill 24–26 by 12–14; wing 297–304; tarsus 38–40; middle toe 39–42; middle claw 13 mm. The whole being from Cape Adare, Victoria Land, and thereabouts."

Presumably Mathews based his conclusions on a selection only of the birds collected by the "Southern Cross," "Discovery," and "Morning" Expeditions, and had he been able to include the additional specimens brought back by the "Terra Nova," as well as those collected by the naturalists on the "Erebus" and "Terror," which in many cases, till this investigation was begun, had very incomplete data, he would have been unable to separate the two species so easily.

With the exception of a single male from Petermann Island, Graham Land, in the Paris Museum, which has a bill of 24 mm., all the examples from the Weddell Sea, Graham Land, South Georgia, South Shetlands, and South Orkneys have bills of under 23 mm. in length, and it is these birds we presume that Mathews considers to be the typical *Pagodroma nivea nivea* of Forster, but how it is to be distinguished from small Ross Sea birds—his *P. n. candida* Peale—we are at a loss to understand.

As we have already said, till further specimens are taken on their breeding grounds, we do not see how any useful attempt can be made to divide this petrel into species and races. That there is more than one species, a large and a small, is highly probable, but at present we can but give detailed measurements of the specimens in the British, Tring, Royal Scottish, Paris and New York Museums (see Table on pp. 144–5, in which British Museum specimens are indicated by registered number).

24. *Macronectes giganteus* (The Giant Petrel, or Nelly). Text-fig. 20.

Procellaria gigantea Gmelin, Syst. Nat. i, pt. ii, p. 563, 1789 (Staten Island); *Ossifraga alba* Potts, Trans. New Zealand Inst. vi, p. 152, 1874 (Foveaux Straits, New Zealand); *Ossifraga gigantea* Salvin, Cat. Birds, xxv, p. 422, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 93, 1907; *Macronectes giganteus solanderi* Mathews, "Birds of Australia," ii, p. 187, 1912 (Falkland Islands); *Macronectes giganteus halli* Mathews, *loc. cit.* p. 187, 1912 (Kerguelen Island); *Macronectes giganteus wilsoni* Mathews, *loc. cit.* p. 189, 1912 (Ross Sea); *Macronectes giganteus forsteri* Mathews, *loc. cit.* p. 189, 1912 (Valparaiso Bay); *Macronectes giganteus dovei* Mathews, Austrl. Av. Rec. iii, p. 54, 1916 (Sydney).

MATERIAL OBTAINED

No. 4. ♀ 18.i.1912. 77° 22′ S., 165° 22′ E., McMurdo Sound. J. H. Mather. Bill whitish horn-colour; legs and feet dusky becoming almost black at edges of webs; toes dark horn shading into black.

No. 5. ♀ 18.i.1912. 77° 22′ S., 165° 22′ E., McMurdo Sound. J. H. Mather. Bill whitish-horn colour; legs and feet dusky becoming almost black at edges of webs; toes dark horn shading into black.

"Stomach absolutely full of rope yarns."

No. 6. 18.i.1912. 77° 22′ S., 165° 22′ E., McMurdo Sound. J. H. Mather. Bill whitish-horn-colour; legs and feet dusky, becoming almost black at edges of webs; toes dark horn shading into black.

Stomach "full of garbage, chiefly rope yarns, and one large smooth pebble about the size of a haricot-bean."

No. 7. ♀ 19.1.1912. 77° 15′ S., 165° E.

No. 8. ♀ 24.i.1912. 77° 05′ S., 164° 117′ E. "Stomach quite empty."

No. 9. ♀ 27.i.1912. 77° 05′ S., 164° 30′ E. J. H. Mather. Iris dark reddish-brown; bill pale yellowish-grey; legs and toes dark grey; webs whitish-grey; claws white, tinged with bluish-green at base; inside of mouth and tongue white.

No. 10. ♀ 31.i.1912. 77° 32′ S., 165° 38′ E. J. H. Mather. Bill whitish horn-colour; legs and feet becoming almost black at edges of webs, toes dark horn, shading into black.

No. 63. 29.i.1912. Cape Evans. H. Ponting. Weight 8 lbs. 6½ ozs.

No. 65. 9.ii.1912. Cape Evans. H. Ponting. Iris brown; beak pink, shading into bluish-brown; legs brown; webs bluish-grey; nails black and white horn.

Systematic Notes.—The typical bird, *Macronectes giganteus giganteus*, comes from Staaten Island, and G. M. Mathews regards examples from South Orkney as being identical. We have no specimens from either of these localities, but we have examined a series of six skins from the South Shetlands which may be considered typical.

According to Mathews, also: "At the Falkland Islands there breeds a uniformly coloured dark bird, almost black, as Wilson puts it—which is smaller than the southern bird. Its bill is very pale and clear and—according to Wilson—lemon-yellow," and this race he has named *M. g. solanderi*.

As far as we know, Wilson never landed at the Falklands nor did he bring back any specimens from the vicinity of these islands, and, as we point out below, birds of all shades are found in these islands.

There are no specimens from the Falkland Islands in the Tring Museum and only one in the British Museum—an unsexed greyish-brown bird with deformed bill, collected by Leconte in 1867–68.

Macronectes g. halli is the name given by Mathews to the sub-species found on the Kerguelen Islands. Of this bird he says in his original description:—"On Kerguelen Island breeds another uniform phase, which is easily separable by its longer and more massive bill, and while shorter in the wing than the Antarctic forms, has the tarsus and toes fully as long. Its general colouration is brown, while all specimens I have examined have more or less whitish faces."

Apparently the specimens which Mathews examined when making the above

description were the series of five birds, two from Kerguelen and three from Crozets —in the British Museum, since he had no examples in his own collection, nor are there any in Lord Rothschild's. All the birds in this series are entirely dark brown, except for the throat and forehead, which are whitish, and with the exception of one female skin from Possession Island the bills and tarsi are above the average in length. This race may perhaps be worthy of recognition.

Ossifraga alba, the name given by Potts to a white example of the Great Petrel from Foveaux Strait, is used by Mathews as *Macronectes g. albus* for birds found in the New Zealand Seas and breeding on the Chatham, and perhaps Antipodes and Campbell Islands. This race, Mathews says, is uniformly dark-coloured, darker than the Kerguelen birds, with a much smaller bill and shorter tarsus. White examples of this race Mathews considers to be albinos, and if that is the case then albinos are very prevalent, since in the twenty-five examples of this bird we have examined in the British and Tring Museums, ten are white with odd black feathers and all have horny-coloured bills and grey legs and feet, with the exception of one bird in the British Museum from Snares Island, in which they are yellow. In Lord Rothschild's collection there is a pure white bird from Snares Island in which both the bill, feet and legs are yellow, and this bird may *perhaps* be an albino, but certainly the other birds cannot be classed as such any more than can the white birds found anywhere else.

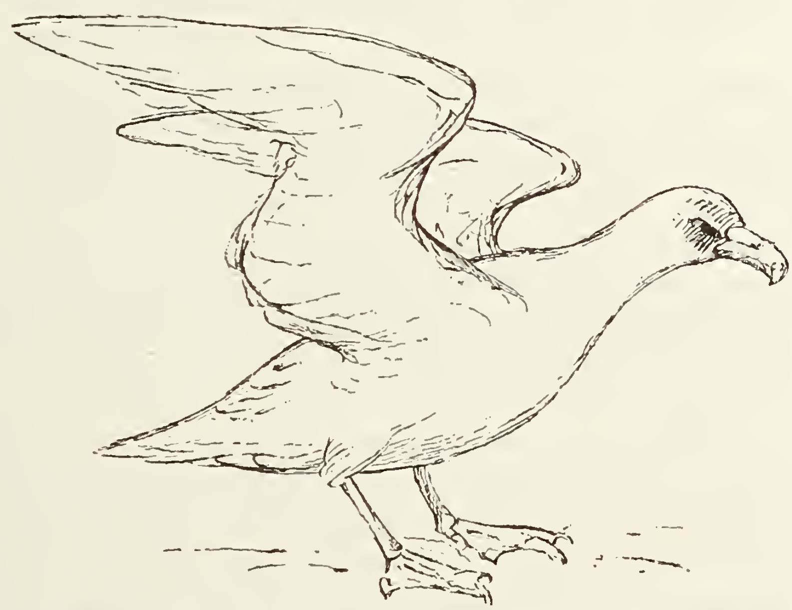

FIG. 20.—Giant Petrel, or Nelly (*Macronectes giganteus*). Alighting on the ice.

As will be seen from the table of measurements, New Zealand birds are certainly smaller on the average than those from Kerguelen, but neither in colour nor size do they differ in any appreciable extent from those inhabiting the Ross Sea.

Birds from Sydney have been named by Mathews as *Macronectes g. dovei*, "differing from *M. g. giganteus* in smaller size," but no details are given how this sub-species can be distinguished from the New Zealand one.

We have measured a series of sixteen birds from Broken Bay, New South Wales, formerly in Mathews's collection and now at Tring, and though the largest birds are certainly larger than the largest from South Shetlands, the average measurement is

practically the same. This series was obtained in March, August, and September, and all the birds with one exception are *labelled* as females, and also all of them are dark except one female, which is white with odd black feathers. *M. g. wilsoni* Mathews, from the Ross Sea is described as : "of very large size and notably paler colouration, a majority being almost white and to which has been attached the Macquarie Island birds."

The Ross Sea birds, as will be seen from the table of measurements, cannot be called very large ; the largest bill is 101 mm. in length and the longest tarsus 100 mm. as against bills of 103 and 106 and tarsi of 98 and 100 in birds from the Sub-Antarctic Islands and New Zealand respectively. We think, however, that it is a gross exaggeration to say that "a majority being almost white," a statement certainly never made by Wilson, who in his report says, that roughly he noted between 66° 7′ S. and 78° S., Dark birds, about 60 ; Intermediate, 14 ; White, 18.

We have had at our disposal for examination, either in the British Museum or in Lord Rothschild's collection at Tring, a very fine series of this Giant Petrel (for lists, see below), about which various opinions have been held in the past in regard to the significance of the several colour-phases which it exhibits. This Giant Petrel, "Bone-breaker," "Nelly," "Stink-pot," or "*Quebranta-huessos*" of the early Spanish voyagers, is nearly as large as a Wandering Albatross. It combines in its large and rather clumsy person the disagreeable characters of a scavenger, a vulture, and a rapacious hunter of smaller marine birds. It is circumpolar in its area of distribution, which comprises a belt extending roughly as far north as 35° and as far south as the northerly fringes of Antarctica.

Within this circumpolar belt the Giant Petrel, as far as is known, does not breed either in Antarctica or on any other continental land, its nesting-places being confined to Southern Atlantic or sub-Antarctic islands, such as Tristan da Cunha, Gough Island, and the Falkland Islands ; South Georgia, the South Orkneys and South Shetlands ; Kerguelen, Prince Edward Island, Marion Island, the Crozets and Heard Island ; and the sub-Antarctic islands of the New Zealand quadrant, such as the Macquaries, Aucklands, and Campbell Island.

Two subsidiary zones or belts have been distinguished by some authors in this extreme southern area of distribution—a sub-Antarctic and an Antarctic, both being circumpolar ; while *correlated with each zone* it has been maintained that there is a more or less definite colour phase. It has, for example, been sought to show that in the northerly belt (South Atlantic) a more or less uniformly brown or dark bird exists, while in the more southerly, or antarctic zone, a pure white form has been evolved, or is in process of evolving. Ogilvie Grant (in MSS.) even went so far in some preliminary work on this report as to recognise two definite species corresponding to the two zones. Thus he writes :—"I am able to distinguish two species of Giant Petrel,

(1) a more southern form with dimorphic plumage—a greyish-brown phase and a white phase—met with from about 45° south latitude southwards to about 75° ;

(2) a more northern dark sooty-brown form with a lemon-yellow bill, met with from about 35° to about 55° south latitude."

While there may be some truth in the assertion that the percentage of dark birds preponderates in the northern zone, while that of the white phase rises higher in the south, we feel sure that the solution of the problem this Petrel presents is comprised in the life-history of one species only and the relative proportions of some four or more colour-phases which characterise it. In the oceanic islands enumerated above, huge communities of breeding birds are annually concentrated, and while we believe that these colour-phases may vary in proportion geographically, we also believe that each phase is represented in every breeding area of any extent. As we shall point out further on, we also believe that at least four of these colour-phases are constant and may be described as " all whites," " all browns or darks," " white heads," and " grey necks."

When Wilson in the " Discovery " was passing down south past the Macquarie Islands and the Aucklands, he noted *Macronectes* in large numbers, " almost all of which seemed to be somewhat small and grey, instead of brownish-black, as though they were perhaps the hen birds or the young of a nesting colony." But, as far as we are aware, there is no difference, certainly none which could be noted at sea, between the juvenile and fully adult plumage of *Macronectes*, and the only conclusion we can draw is that the proportion of " grey-necks," relative to other phases, about the islands south of New Zealand may be prominent, but this conclusion, of course, is drawn in the most tentative and suggestive way, for it is obvious that the whole subject requires a great deal more investigation. The little that has yet been done seems to confirm the opinion we have expressed as to the presence throughout the whole area of distribution of this species of at least four colour-phases. For instance, Mr. G. E. Ainsworth, who was left with a party on Macquarie Island during Sir Douglas Mawson's Antarctic Expedition, and who studied the bird-life of that island, says :—" The colour ranges through various shades from almost pure white to a dark greyish-brown, *some even appearing almost black !* " (italics ours). So that it is clear we get the full range of colour, or perhaps better, the two extremes, dark and light, even in this southern zone of the bird's range. Passing to the Falklands, that is to say, to the penultimate northern distribution of the species, we find Mr. Rollo H. Beck, in the American Museum Journal (1917, xviii, No. 456), publishing a very fine photograph of a sitting colony of these birds, in which at least a hundred examples are shown. In this photograph there is nothing to belie the statement that " grey-necks " and " white-necks " are the commonest phases present and commoner than " all blacks."

Wilson's observations made on the " Discovery " in regard to the Giant Petrel cannot unfortunately be quoted in full here, but as to the relative distribution of the various phases of this bird he has some interesting notes made during the course of the voyage and while in the ice. The conclusion he came to was that " the white form, although seen from time to time in the more temperate region of the Southern Ocean,

is really very much more abundant, both absolutely and relatively, in the ice. And not only this, but that the abundance of the intermediate forms has also some relation to locality and climatic differences." He goes on to say that "in a voyage of 140 days, covering many thousands of miles of the sub-Antarctic ocean, only one White Giant Petrel was seen among several hundred of the uniformly darker ones, giving a very small percentage, and also that the percentage of intermediate forms is almost as small, amounting to three or four in all, or less than a half per cent. Whereas if we compare this with the proportion of White to Dark and Intermediate birds in latitudes where ice conditions are persistent, we see that in a total of about a hundred birds observed during half as many days, in a voyage covering only about 4,000 miles, the percentage of intermediate birds rises to $23\frac{1}{3}$ per cent., and of white to as much as 30 per cent. Thus :—Between 33° S. and 66° 7′ S., we observed :—

Dark birds.	Intermediate.	White.
At least 500	4	1

Whereas, between 66° 7′ S. and 78° S. we observed :—

Dark birds.	Intermediate.	White.
About 60	14	18

The fact that the relative abundance of the white phase to others increases as we proceed south, is partly confirmed by the observations of Mr. Bennett (in litt.). For example, he states that in the Falklands (New Island) the white phase is represented by a population of 2 per cent. only, whereas in the South Shetlands (Deception Island) "I have many times counted up to twelve hundred, and the proportion of whites is, I am now satisfied, $12\frac{1}{2}$ per cent." Again, writing of New Island (Falklands), he says "the white ones are scarce, grey-necks and white-necks abundant, and sooty-black are equally numerous." At the South Shetlands grey-necks amounted to 40 per cent. and "all brown" to 50 per cent. We shall refer again to the "all-browns," which we suspect are faded "sooty-blacks."

Other observers have quoted figures which seem to fall into line with Wilson's observations. For example, Eagle Clarke (Scottish Antarctic Expedition, *Ibis*, 1906, p. 172) estimates the all-white form on the South Orkneys at 2 per cent. ; while the same phase around Graham's Land, according to Mr. Burn Murdoch, was estimated at 5 per cent. Moreover, all observers seem to be agreed that the more northerly bird is a dark bird and this seems especially to be applicable to the Kerguelen Island area.

It must be remembered, however, that none of the old observers paid any particular attention to problems of this kind, so that the relative proportions of colour-phases present in any island community were never noted. Thus, although Eaton and Kidder were on Kerguelen in connection with the "Transit of Venus" operations, we learn little or nothing from their observations. Indeed, if we may judge from John Nunn's "Narrative of the Wreck of the 'Favorite,'" written in 1850, the white phase

of *Macronectes* was actually present on the island in his time. Mr. Robert Hall, however (*Ibis*, 1900, p. 27), records finding "some twenty-one fledglings, as large as full-grown geese, in a rookery on Kerguelen, all in grey down (? bluish-grey)." This, it may be noted, is in contrast to the pure white down of the "white phase." He says, too, "I found several young birds which had just lost their grey down, and had assumed a *shining black plumage*" (italics ours), but as we shall again note similar chicks in blue-grey down occur in the South Shetlands alongside chicks in pure white down and both respectively and immediately assume a pure black and a pure white plumage, which does not appear to differ in any respect from a fully adult plumage. We cannot, therefore, feel sure that the white phase does not, or at any rate did not, occur on Kerguelen although we have no specimens in the British Museum. We do learn, however, from Layard ("Birds of South Africa") that "a white variety is common up the west coast (of South Africa) towards Walfish Bay."

It may be stated here that former writers, Butler being included in the number, originally regarded the white phase of *Macronectes* as an example of albinism, while even Mathews in his "Birds of Australia" had not entirely relinquished the idea, as may be noted below. That the "all-white" phase without any trace of black feathers scattered about the body as in the more normal "white phase," is not due to albinism is, I think, conclusively proved by Menegaux (Expéd. Antarctique Française, 1903–5), who records an example of this kind taken in the South Shetlands, as having an iris "brun-marron." It was taken with two others of the normal white phase.

When G. M. Mathews was engaged on the work just mentioned, it may also be noted that the opinion still prevailed that "the oldest birds are pure white, and the youngest are the darkest coloured; but the latter are much lighter than the lightest coloured northern birds, where also the youngest are darkest" (cf. vol. ii, p. 1888). This we feel convinced is not correct.

As regards our own conclusions, it seems first of all quite clear, judging from examples of chicks in down taken on the same day from the same colony and the same locality on the South Shetlands, that the chick of the Giant Petrel moults directly from the down into a phase of plumage which is identical with that of the adult. There are, for example, in the British Museum two big chicks in down from these islands; in one the down is pure white, while at the base of the down feathers pure white feathers, in all respects similar to adult feathers, are coming through carrying the down feathers on their tips. Every here and there pure black feathers may be seen, as in adults of the "white" phase, scattered indiscriminately among the white plumage. In the other chick, the down is a blue-grey or greyish-slate colour, and similarly the feathers coming through and carrying the down on their tips are deep black and cannot be distinguished from adult feathers. They correspond to the "black" or "all brown" phase. It is clear, therefore, that the "white" and "black" colour-phases have no relation to the age of the bird. They breed true *de natu* and so continue fixed

throughout the life of the bird. That the "all brown" phase, alluded to by Mr. Bennett in his description (in litt.) of South Shetland rookeries, represents nothing more than faded "sooty-blacks" seems most probable, although only actual study on the spot will settle the point.

There is good reason to believe from the series of skins we have studied and from the notes of observers in the field, especially those of Mr. Bennett of the Falkland Islands, that in addition to "white" and "black" phases there are at least two other colour-phases, which, in the words of Mr. Bennett, may be described as "white-necks," "grey-necks," and "all-browns." As we have just said, we should be prepared to find that the "all-browns" were merely faded "all-blacks."

Unfortunately, we have no chicks in down with which to prove that these last colour-phases originate *de natu,* as in the "white" and "black" phases; and this because collections of birds in the field were often made in the past in such a haphazard fashion, while the importance of collecting chicks and other plumage phases was overlooked. Nevertheless, we believe that it will eventually be demonstrated that the "white-necks," "grey-necks," and "all-browns" do not represent phases of plumage correlated with age, but correspond to distinct colour categories.

In support of this we may say that we have examined every bird of the large series measured for moult, and though there was ample evidence of moulting we did not see any juvenile down. In every case where a bird was moulting, whether blackish-brown, grey, white, etc., the new feathers coming in were similar though naturally of a richer or darker colour as fresh feathers are.

In any breeding community of Giant Petrels all the evidence seems to point to the fact that all these four or five colour-phases occur together, except possibly in Kerguelen, where it appears from the accounts of voyagers and naturalists that the "black" or "all brown" phase has become entirely predominant. It seems clear, in fact, that in the various breeding or other communities at present studied, the relative proportions of the colour-phases represented may vary either geographically, seasonally, or according to mendelian ratios.

Since writing the above we have read Mr. L. Harrison Matthews' remarks on *Macronectes* in his account of the birds of South Georgia included in the "Discovery" Reports. Through the courtesy of Dr. Stanley Kemp we are enabled to reproduce them here :—

"There are three main phases of plumage in the Giant Petrel—dark, light, and intermediate. The intermediate one is the most common in South Georgia, the next in numbers being the dark one, while the light one is represented by a very small percentage. The colour phases mingle indiscriminately in nesting. The few white examples found nesting in South Georgia were all paired with dark or intermediate ones. In the South Orkney Islands, where the white phase is much more numerous, some white ones were seen paired together, but this was evidently haphazard and only due to the higher proportion of them, as others were seen paired to intermediate birds."

MEASUREMENTS OF *MACRONECTES GIGANTEUS* IN BRITISH AND TRING MUSEUMS

FALKLAND ISLANDS AND CHILI

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of bill.*	Depth of bill.†	Tarsus.	
1928.7.21.4	♂	1.ix.1927	Estancia Viamonte, Tierra d. Fuego	P. W. Reynolds	94	37	92	Very dark.
1888.5.18.1031			Falkland Islands	Leconte	80	31	85	Blackish-brown, white head.
1879.9.3.53	♂	13.iv.1879	Tom Bay, Strs. Magellan	Coppinger	86	32	85	Black.
1886.2.1.24			34° S., 10° 24′ W.	Earl Crawford	106	37	98	Ditto.
1886.2.1.23			34° S., 10° 24′ W.	,, ,,	88	35	97	Ditto.
1845.6.12.18			Valparaiso, Chile	Capt. Brett	83	30	82	Dark sooty-brown all over. Moulting.
1892.2.10.401			,, ,,	H. Berkeley James	82	32	82	Ditto.
1880.2.3.5.	♂	4.viii.1879	,, ,,	Dr. Coppinger	97	36	93	Dark sooty-brown all over. Legs black, bill grey, eyes dark.
1903.12.30.203	♀	17.ii.1903	,, ,,	M. J. Nicoll	88	34	89	Dark sooty-brown appearing paler on neck and breast owing to wear. In moult.
1885.5.18.104	♀	xi.1881	Coquimbo Bay, Chile	Capt. A. H. Markham	100	37	88	Similar, but paler on throat. In moult. Eyes brown.
1880.11.18.635	♀	5.xi.1875	S. Pacific	"Challenger" Exp.	101	37	97	Dark sooty-brown all over, many feathers with pale worn edges, contrasting with dark fresh feathers. Moulting.
SOUTH GEORGIA AND SOUTH SHETLANDS								
1914.3.8.12	♀	7.xii.1913	South Georgia	P. Stammwitz	87	34	91	Brown, white forehead, chin and throat coming in slightly darker. Probably really the same colour but new feathers fresh.
1914.3.8.6.	♀	2.i.14	,,	,,	90	32	87	Ditto. Moulting in same.
1914.3.8.14	♀	12.xi.1913	,,	,,	90	34	89	Throat grey, but otherwise the same. Moulting in same.
1914.3.8.15	♀	30.xii.1913	,,	,,	90	32	88	Dark bird. White forehead and throat. Moulting in dark feathers.
1914.3.8.16	♀	2.i.1914	,,	,,	89	36	88	Ditto; also moulting.
1914.3.8.17	♀	2.i.1914	,,	,,	84	33	88	Dark bird, pale throat; not moulting.
1914.3.8.11	♀	24.xii.1913	,,	,,	86	36	89	Pale grey-brown above, dirty-white head, throat and belly. Moulting in same colour.
1914.3.8.20	♀	2.i.1914	,,	,,	89	34	89	Brown head, neck and throat white, crown grey-brown. Moulting on breast.
1914.3.8.19	♀	7.xii.1913	,,	,,	89	37	91	Grey-brown, head and hind neck same colour, throat white. Moulting on back to same colour.
1914.3.8.10	♀	15.xi.1914	,,	,,	89	36	85	White with a few black feathers. Both moulting in again.
1922.12.6.10	♀	21.xii.1921	,,	Wilkins	100	38	98	White with black feathers.
1922.12.6.9	♀	31.xii.1921	,,	,,	88	34	88	Ditto.
1914.3.8.13	♂	30.xii.1913	,,	Stammwitz	103	40	103	Grey phase, white throat. Moulting.

* Measured from feathers on forehead to tip.

† Measured at greatest depth behind the narial tubes.

MEASUREMENTS OF *MACRONECTES GIGANTEUS* IN BRITISH AND TRING MUSEUMS—*continued*

SOUTH GEORGIA AND SOUTH SHETLANDS—*continued*

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of bill.*	Depth of bill.†	Tarsus.	
1914.3.8.18 ..	♂	12.xi.1913		Stammwitz	88	35	96	Grey-brown, head and hind neck same colour, throat white. Moulting in on back same colour.
Tring Mus.	♂			Steiner German Exp.	100	38	93	Blue-grey, paler on neck, throat and sides of neck and top of head grey. Moulting in same.
1914.8.12.1	♂	14.iii.1914	Deception Is., S. Shetlands ..	A. G. Bennett ..	99	37	95	Grey-brown all over. Moulting in same colour.
1914.8.12.2 ..	♂	10.iii.1914	" " " ..	" ..	94	34	93	Blue-grey on back, paler throat and breast. Moulting in same colour on back.
1914.8.12.3 ..	♂	13.iii.1914	" " " ..	" ..	99	37	95	White with black feathers here and there. Moulting in same.
1914.8.12.4 ..	♂	13.iii.1914	" " " ..	" ..	100	38	93	Very dark bird. Moulting in same.
1924.5.8.26 ..	♀	26.i.1924	" " " ..	J. E. Hamilton ..	85	32	89	White with black feathers here and there. Moulting in same.
24.5.8.27 ..	♀	8.i.1924 ..	" " " ..	" ..	83	34	88	Grey. Throat lighter. Moulting in same.
				ROSS SEA AREA				
1905.12.30.393	♂	9.i.1902 ..	Cape Adare, No. 23	"Discovery," E. A. Wilson.	100	38	96	White with odd dark feathers. Iris brown, bill dull yellow, legs and feet grey.
1905.12.30.394	♂	9.i.1902 ..	" No. 24	" "	100	40	98	White with odd dark feathers. Iris brown. Moulting in same.
1905.12.30.405	♂	8.i.1902	"	Dr. A. G. Davidson, "Morning."	100	39	100	Ditto, ditto.
1916.6.20.103	♀	31.i.1912	McMurdo Sound, 10′ W. of Cape Royds.	"Terra Nova," J. H. Mather.	90	34	90	White with odd dark feathers. Moulting.
1916.6.20.102	♀	27.i.1912	77° 35′ S., 164° 30′ E. Entrance to McMurdo Sound.	" "	90	35	93	Ditto, ditto.
1901.1.7.31 ..	♀	13.i.1900	Cape Adare	"Southern Cross," N. Hanson.	85	32	89	White with many dark feathers on back, some of which are greyish-white. Moulting in same.
1905.12.30.406	♀		69° S., 178° E., N.E. of Cape Adare, No. 29.	Dr. A. G. Davidson, "Morning."	95	34	92	Dark body, paler on throat. Moulting.
Tring Mus.	♀	2.i.1900 ..	Cape Adare		99	38	95	Dark bird, throat whitish, belly lighter than N.S.W. birds. Moulting in same.
1916.6.20.98	♀	18.i.1912	77° 20′ S., 165° McMurdo Sound ..	"Terra Nova," J. H. Mather.	90	35	92	Dark except on throat and upper neck, which are white. Moulting.
Brit. Mus. ..		i. 1904 ..	Cape Royds		101	37	95	Dark brownish-grey all over, throat lighter. Moulting.
1901.1.7.28 ..	♀	16.i.1899	65° 43′ S., 164° 9½′ E.	"Southern Cross," N. Hanson.	85	33	89	Dark brownish-grey, lighter on throat. Moulting in same.
1901.17.30. ..	♂	2.i.1900 ..	Cape Adare	"Southern Cross," H. Evans.	100	39	97	Brownish-grey, brownish-white on throat, paler on head and abdomen. Moulting in same.
1905.12.30.395	♀	23.xi.1903	McMurdo Strait. No. 21	"Discovery," E. A. Wilson.	88	34·5	87	Brownish-grey above, head and neck paler, below greyish-white. Moulting in same, many old feathers much worn. *Iris* brown and ochre, *bill* dull yellow, *feet* and *legs* grey.
1905.12.30.396	♀	12.xi.1903	McMurdo Strait. No. 20	"Discovery," E. A. Wilson.	86	33	91	Similar to above but underside and head also dark, throat yellowish-white. Soft parts same. Moulting in same.

1905.12.30.397	♀	20.i.1904	Cape Royds. No. 19	"Discovery," E. A. Wilson.	87	33	88	Similar to 395, but pale head. Moulting in same.
1916.6.20.96	♀	9.xi.1912	Cape Evans	"Terra Nova," E. A. Wilson.	86·5	35	90	Lighter above, head mixed white and brownish-grey, throat white, underside greyish-brown. *Beak* pink, shading into bluish-brown; *legs* brown streaky; *webs* bluish-grey; *iris* brown. Moulting.
1916.6.20.101	♀	24.i.1912	77° 05′ S., 164° 17′ E. McMurdo Sound.	"Terra Nova," J. H. Mather.	92	35	92	Grey above, paler below, white head, neck and throat. Moulting in same.
1916.6.20.100	♀	19.i.1912	77° 20′ S., 165° E. McMurdo Sound	,, ,,	89	33	90	Grey above, darker below, white head, neck and throat. Moulting in same.
1916.6.20.97	♀	18.i.1912	77° 20′ S., 165° E. McMurdo Sound	,, ,,	91	36	93	Grey brown, white neck and head. Moulting.
1916.6.20.99	♀	19.i.1912	77° 20′ S., 165° E. McMurdo Sound	,, ,,	88	34	89	Ditto, ditto.
1916.6.20.95		29.i.1912	Cape Evans		90	35	90	Greyish-brown above, greyish-white below, throat white, moulting in same.
			NEW ZEALAND AND SUB-ANTARCTIC ISLANDS					
1893.12.4.2.			Snares Is., New Zealand		88	34	88	White with odd black feathers.
Tring Mus. ..	♂		,, ,, ,, ...	Dannefaerd	86	34	90	Ditto.
,,	♂		,, ,, ,, ...	,, ...	102	39	96	Ditto.
,,	♀		,, ,, ,, ...	,, ...	92	33	90	Pure white, feet now yellow, not dark like other birds, but also of same colour—not horny.
,,	♀		,, ,, ,, ...	,, ...	98	38	98	Grey on back, white shoulder of wing. Neck and head dirty-white with few grey feathers, belly grey. Moulting in same.
,,		vi.1895.	,, ,, ,, ...	H. H. Travers ..	98	35	92	White with odd black feathers.
,,		30.v.1894	,, ,, ,, ...	H. H. Travers (*ex* Buller Coll.).	104	39	100	Ditto.
1875.7.2.22			Wellington, New Zealand	Colonial Mus. ..	85	31	87	Black-brown with pale throat.
Tring Mus. ..			*ex* Mathews Coll. fig. Bds. N.Z. ..		99	35	95	All black-brown.
,, ..			*ex* Buller Coll., New Zealand ..		95	26	96	Ditto.
,, ..			,, ,, ,, ,, ..		88	33	87	Blackish-brown on back, neck white with brown feathers, head same, throat and neck white, breast grey, belly blue-grey. Moulting in same.
,, ..			,, ,, ,, ,, ..		106	28	96	Brown above, neck greyish-brown, head white with grey throat, sides of head white, below grey. Moulting in same.
,, ..			,, ,, ,, ,, ..		93	35	92	Dark on back, brownish below.
,, ..	♂		,, ,, ,, ,, ..		99	34	95	White with odd black feathers.
,, ..	♂		,, ,, ,, ,, ..		88	32	84	Ditto.
,, ..			*ex* Mathews Coll., Lord Howe Is. ..		103	—	100	Very dark (burnt on throat).
1887.7.5.1 ..		ix.1885 ..	Norfolk Is.		87	34	88	Very dark brown.
Tring Mus. ..		1890 ..	Chatham Is.	Palmer	96	34	91	Grey intermediate form, cheeks lighter.
,, ..			,, ...		86	33	84	Grey intermediate form, pale on throat.
,, ..			,, ...		94	36	88	Ditto, ditto. Moulting in same.
1897.12.6.42	♂		Auckland Is.	Otago Univ. Mus. ..	98	36	32	Brown, pale throat.
1905.12.30.398		2.iii.1904	,, ...	Dr. Souter	101	40	95	Dark brown. Moulting in same.
1905.12.30.166	♂	22.xi.1901	Macquarie Is.	E. A. Wilson ..	101	40	98	Grey, head white. Moulting in same.
1905.2.2.39 ..		13.i.1902	,, ...	Earl of Ranfurley ..	101	37	97	White.
Tring ..		13.ii.1902	,, ...	,, ,, ..	101	35	96	White with black feathers.
1901.1.7.29			Campbell Is.		103	39	97	Ditto, ditto. Moulting in same.

* Measured from feathers on forehead to tip.

† Measured at greatest depth behind the narial tubes.

MEASUREMENTS OF *MACRONECTES GIGANTEUS* IN BRITISH AND TRING MUSEUMS—*continued*

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of bill.*	Depth of bill.†	Tarsus.	
			PACIFIC					
Tring Mus. ..	♀	v. 1875 ..	Kandavu, Fiji	von Hugee	98	—	95	Black-brown all over.
			AUSTRALIA					
Tring Mus. ..	♀	3.viii.1914	Broken Bay, N.S.W., *ex* G.M. Coll.	E. A. Windle ..	84	32	92	Black all over.
,, ..	♀	18.viii.1914	,, ,, ,, ,,	,,	97	25	93	,, ,,
,, ..	♀	9.viii.1914	,, ,, ,, ,,	,,	96	36	93	,, ,,
,, ..	♀	3.viii.1914	,, ,, ,, ,,	,,	98	37	95	,, ,,
,, ..	♀	5.viii.1914	,, ,, ,, ,,	,,	96	34	94	,, ,,
,, ..	♀	13.viii.1914	,, ,, ,, ,,	,,	102	37	96	,, ,,
,, ..	♀	1.viii.1914	,, ,, ,, ,,	,,	105	27	101	,, ,,
,, ..	♀	7.viii.1914	,, ,, ,, ,,	,,	98	27	98	,, ,,
,, ..	♀	11.viii.1914	,, ,, ,, ,,	,,	82	32	88	,, ,,
,, ..	♀	5.viii.1914	,, ,, ,, ,,	,,	101	38	96	,, ,,
,, ..	♀	1.viii.1914	,, ,, ,, ,,	,,	102	27	97	,, ,,
,, ..	♀	16.iii.1913	,, ,, ,, ,,	,,	98	27	96	,, ,,
,, ..	♀	9.viii.1914	,, ,, ,, ,,	,,	84	24	87	,, ,,
,, ..	♀	7.viii.1914	,, ,, ,, ,,	,,	84	24	88	,, ,,
,, ..	♀	4.ix.1914	,, ,, ,, ,,	,,	84	25	89	White with odd black feathers.
,, ..	♂	7.viii.1914	,, ,, ,, ,,	,,	92	34	90	Black, worn feathers brownish on neck and belly.
				,,				Moulting in same.
			KERGUELEN AND CROZETS					
1891.6.16.6	0	23.v.1849	Kerguelen	R. McCormick ..	108	39	—	Dark brown, throat whitish. Moulting in same.
1841.734 ..			,, ...	Antarctic Exped. ..	104	40	92	Dark brown.
1888.11.18.634	0		,, ...	"Challenger" Exped.	107	40	99	Dark brown, throat and forehead whitish.
1909.11.16.3	♂	4.i.1908 ..	Possession Is., Crozets	Capt. Th. King ..	106	41	101	Ditto, ditto. Moulting in same.
1909.11.16.1	♀	4.i.1908	,, ,, ...	,, ,,	93	35	93	Ditto, ditto. Moulting in same.
1909.11.16.2	0	xii.1907 ..	,, ,, ...	,, ,,	106	41	99	Ditto, ditto. Moulting in same.

* Measured from feathers on forehead to tip, † Measured at greatest depth behind the narial tubes.

RANGE OF COLOUR AND SIZE IN *MACRONECTES GIGANTEUS* IN DIFFERENT AREAS

	Number of Specimens measured.	Colour.			Bill Length.			Bill Depth.			Tarsus.		
		Dark.	Grey.	White.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Straits of Magellan	2	2	—	—	94	86	90	37	32	34·5	92	85	88·5
Chile	6	6	—	—	101	83	91·8	37	30	34·5	97	82	88·5
South Georgia ..	15	3	9	3	100	84	90·8	38	32	35·2	103	88	90·8
,, Shetlands ..	6	1	3	2	100	83	93·3	38	32	35·3	95	88	92
,, Falklands ..	1	1	—	—	—	—	80	—	—	32	—	—	85
Tristan da Cunha ..	2	2	—	—	106	88	97	37	35	36	98	97	97·5
Ross Sea	21	3	12	6	101	85	92	40	32	35·3	100	88	92
New Zealand ..	15	6	1	8	106	85	94·25	39	32	35	100	88	92·1
Sub-Antarctic Islands	9	2	4	3	103	94	97·8	40	33	34·4	98	84	93·1
New South Wales	16	15	—	1	105 *	82	93·9	38	32	35	101	88	93·3
Kerguelen	5	5	—	—	108	93	104	41	35	39·2	101	93	98

* 8 measured.

25. *Daption capensis* (The Cape Pigeon).

Procellaria capensis Linné, Syst. Nat. 10th ed., p. 132, 1758 (Cape of Good Hope); *Dapiion capensis* Salvin, Cat. Birds Brit. Mus. vol. xxv, p. 428, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 102, 1907; *Daption capensis australis* Mathews, Austral. Av. Rec. vol. i, p. 187, 1913 (New Zealand).

MATERIAL OBTAINED

No. 33.	♀ 10.ix.1910.	38° 58′ S.,	35° 24′ E.	A. Cherry-Garrard.
No. 34.	♀ 11.ix.1910.	39° 50′ S.,	37° 56′ E.	,,
No. 35.	♀ 12.ix.1910.	39° 57′ S.,	40° 34′ E.	,,
No. 38.	♂ 5.x.1910.	41° 49·8′ S.,	118° 01′ E.	,,
No. 39.	♀ 5.x.1910.	41° 49′ S.,	118·01° E.	,,
No. 41.	♂ 8.x.1910.	41° 08′ S.,	128° 43′ E.	,,

Bill black; iris dark brown; legs black, feet black with white spots.

We have examined a large series of this species and can see no difference in colour between New Zealand birds and those from elsewhere.

The first entry of this species in Dr. Wilson's diary is on August 3, 1910, when two were seen, the "Terra Nova" being at the time in 30° 18′ S., 190° 28′ W., and from that date this bird was seen every day until Cape Town was reached.

On August 5, Dr. Wilson writes: "I saw one dip entirely, with half-spread wings, to get a piece of garbage, and reappear with a splash like a Shearwater. To rise from the water it has to run on the surface, four or five splashing steps."

During his voyage in the R.M.S. "Corinthic" from the Cape to New Zealand, Dr. Wilson records the Cape Pigeon daily in his diary, and after leaving Port Chalmers

he has notes of it up till December 9, 1910, in 65° 8′ S., 177° 41′ W., after which date no more were seen.

When the "Terra Nova" was returning from Cape Adare Cape Pigeons were seen in 68° 41′ S., 168° 29′ E., on February 21, 1911, and one was seen next day still further south in 69° 10′ S., 164° 30′ E. From March 5 to 25, in 66° 37′ S., 161° 42′ E., to 50° 10′ S., 163° 14′ E., this species was noted almost every day.

During the second voyage of the "Terra Nova" there are entries in the zoological log of this species from December 20, 1911, in 53° 35′ S., 173° 06′ E., to January 13, 1912, in 76° 54′ S., 166° 39′ E., and northwards again to 54° 03′ S., 167° 18′ E., on March 25.

Only four entries have been made under the "Cape Pigeon" throughout the third voyage, viz :—

December 17, 1912.	49° 12′ S., 178° 14′ W.
December 26, 1912.	63° 43′ S., 166° 36′ W.
December 27, 1912.	65° 53′ S., 166° 03′ W.
January 31, 1913.	63° 14′ S., 163° 39′ E.

While on the voyage home four or five of these birds were seen on April 11, 1913, in 56° 11′ S., 73° 42′ W.

26. *Halobaena caerulea* (The Blue Petrel). Plate III, fig. 1.

Procellaria caerulea Gmelin, Syst. Nat. vol. i, pt. ii, p. 560, 1789 (Southern Ocean 47° to 58°); *Halobaena caerulea* Salvin, Cat. Birds Brit. Mus. xxv, p. 431, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 104, 1907.

The Blue Petrel was first encountered in 46° 30′ S., 116° 07′ E., about the same latitude, but further East, than where this bird was first noted on the outward voyage of the "Discovery" in 1901.

There are only two other notes of this petrel in Dr. Wilson's diary, viz. on December 7, 1910, in 61° 22′ S., 179° 56′ E., when a single bird was seen in a large flock of Prions, and again on the following day, when one or two were seen again amongst some Prions, two degrees further south.

The only observations under the head of this species in the "Terra Nova's" Zoological log are on the voyage out on October 2, 1910, when the bird was seen East of Kerguelen, and later on the return from the first trip to Cape Evans. It was reported on March 9, 1911, in 62° 51′ S., 160° 55′ E. On both these occasions the characteristic white tip to the tail was noted.

Fig. 1, Plate III, is a painting of a Blue Petrel made by Dr. Wilson during the voyage.

27. *Prion* sp. (Dove-Petrel). Plate II, figs. 1–5, Text-fig. 21.

Under the heading of *Prion* sp. ? there are a large number of records both of Dr. Wilson's diary and in the zoological log of the "Terra Nova," but as it is impossible to say what the species are, these records are not given.

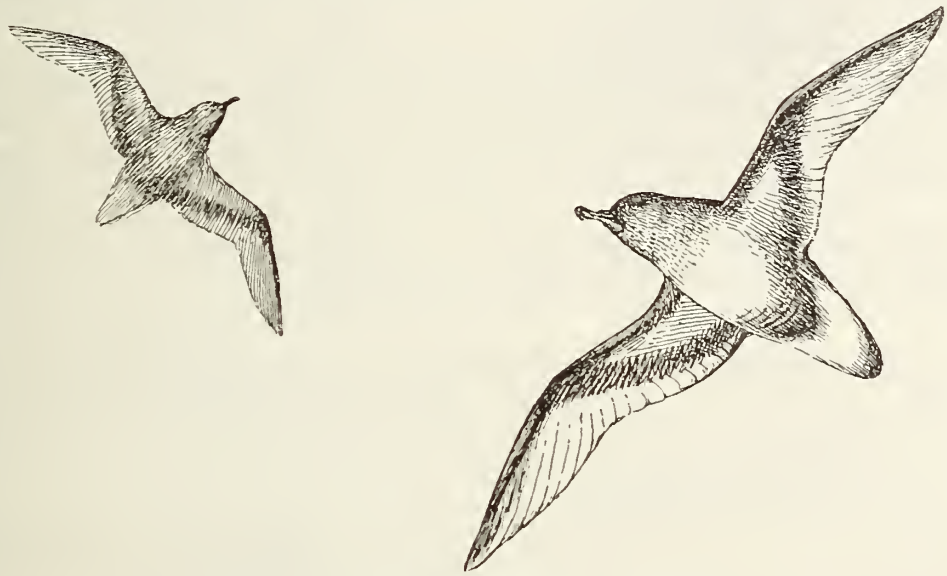

Fig. 21.—Dove Petrel (*Prion* sp.). In flight.

Plate II and Text-fig. 21 are reproduced from a series of studies of *Prions* made during the voyage.

28. *Pelecanoides urinatrix exsul* (Kerguelen Diving Petrel). Text-fig. 22.

Pelecanoides exsul Salvin, Cat. Birds Brit. Mus. xxv, p. 438, 1896 (Kerguelen).

The following notes made by Dr. Wilson, when on R.M.S. "Corinthic" on his way to Melbourne from Cape Town, apparently refer to this Diving Petrel, and a careful sketch which he made is reproduced on the next page.

> *Aug.* 13, 1910.—35° 27′ S., 9° 58′ E., West of Cape Town. Two new Petrels, rather like the Diving Petrels but a good deal larger, flying rather like Guillemots, low on the water and with a good deal of flapping, chiefly round and abeam of the ship, wings set well abaft. Black or very dark above, black collar, white on face, white flanks and lower parts. They flapped quickly, and then sailed for a bit. The flapping was a feature.

Lieut.-Commander Pennell, R.N., gives the following notes: "Pure white below, the white coming high up on the neck and behind the wings. A white streak behind the eye. Flies very low over the surface, flaps its wings hurriedly four or five times and then skims, flaps again and so on. Reminds me both of a flying fish and a Guillemot."

> *Sept.* 17, 1910. 45° 12′ S., 54° 57′ E. S. of the Crozet Is. One of the Diving Petrels: a bird which flew very close over the water, with pointed wings

and very short tail. About the size of *Oestrelata macroptera* or smaller. Very dark above and with a blackish head and collar. (Text-fig. 22.)

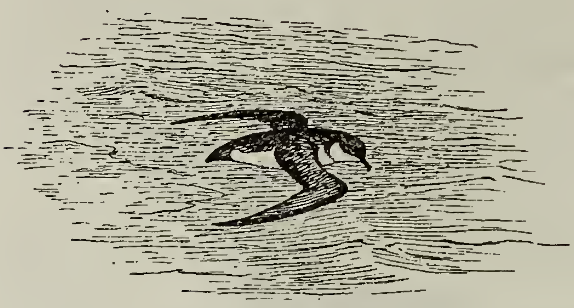

FIG. 22.—Kerguelen Diving-Petrel (*Pelecanoides urinatrix exsul*). In flight (August 17, 1910).

In the evening about 5.30 p.m. there was not a bird to be seen in the wake of the ship or elsewhere. I cannot give any reason for this, unless that all had remained behind for scraps, which is very unusual.

[Commander Pennell in his notes also refers to a Diving Petrel which was seen during the Surveying voyage of the "Terra Nova" around the Three Kings Island, New Zealand. This probably refers to the typical race.]

29. *Heteroprion desolatus alexanderi* (Alexander's Dove-Petrel). Text-fig. 23.

Heteroprion desolatus alexanderi Mathews and Iredale, Man. Birds Austr. i, p. 42, 1921 (West Australia).

MATERAL OBTAINED

No. 36. ♂ 42° 17′ S., 110° 18′ E. A. Cherry-Garrard.

Iris dark brown; bill horn-colour tipped with blue and black edgings; leg and toes greyish-blue, toes beneath nearly black; webs white, smoky on the outer edge.

The above example was caught at sea off the S.W. coast of Australia. The bills of these birds (Text-fig. 23) average longer and wider than bills of birds from Desolation Island and Kerguelen, *H. d. desolatus*.

Two examples of this form were picked up on Cottesloe Beach in West Australia in August, along with others, and were presented to the British Museum by the West Australian Museum.

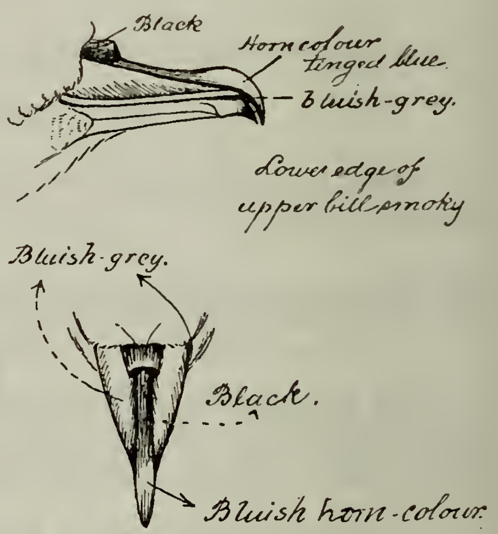

FIG. 23.—Alexander's Dove-Petrel (*Heteroprion desolatus alexanderi*). Bill, to show distribution of colour.

30. *Diomedea exulans* (Wandering Albatross). Plate VIII, figs. 1–8, 11–12; Text-fig. 24.

Diomedea exulans Linn. Syst. Nat. 10th ed., p. 132, 1758 (Cape of Good Hope); Salvin, Cat. Birds Brit. Mus. xxv, p. 441, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 108, 1907; *Diomedea chionoptera* Salvin, Cat. Birds Brit. Mus. xxv, p. 443, 1896 (Kerguelen); Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, p. 110, 1907.

MATERIAL OBTAINED.

No. 44. ♂ 21. x.1910. 44° 30′ S., 155° E., between New Zealand and Tasmania. Iris dark brown; eyelids scarlet; legs, feet and nails pale grey; webs flesh-grey.

In his notes Wilson appears to have been rather confused over the different Albatrosses, writing *Diomedea exulans* or *regia* when apparently he meant *D. exulans* or a sub-species. *Diomedea regia,* now known as *D. epomophora,* is not found outside the Australian Seas. We have combined all Wilson's notes under each date, but have placed in square brackets the name of the bird to which he considered it referred.

Aug. 1, 1910.—26° 38′ S., 22° 43′ W., South-east of South Trinidad Island. [*D. exulans.*] Appeared for the first time—a young bird with almost all the upperparts uniformly brown. It came and got caught in the Tarpon line which we had flying from the halyards. The line broke and the bird disentangled itself, flew off and disappeared.

Aug. 4, 1910.—30° 56′ S., 16° 48′ W., North-West of Tristan da Cunha. [*D. exulans*]. One fully adult with black wings and a conspicuous white patch on each. Also one young one, brown all over the upperparts, white on the face and under the wings.

Aug. 5, 1910.—31° 47′ S., 14° 06′ W., North of Tristan da Cunha. [*D. exulans.*] One fully adult with a white patch on each wing. One adult, with the head, back, and body white, and the wings black, but no white patch.

Sept. 12, 1910.—36° 26′ S., 22° 47′ E., South of Cape Colony. [*D. exulans.*] Six or seven adults all day, and several in intermediate stages of plumage. One quite young was almost all brown on the upperside.

[*D. regia.*] One only all the day.

Sept. 13, 1910.—38° 57′ S., 28° 43′ E. [*D. exulans.*] Several all day, quite adult ; *i.e.* clean white backs, with sharp cut black wings and a well-marked white patch on each wing. One bird yesterday had clean white back and quite black wings with no white patch. Several young ones to-day were brown all over the back and wings, as were the head and neck on the upper surface—whitish on the underneck and throat, except for a broad brown band under the lower neck. Young *D. exulans* can always be distinguished from the Giant Petrel (*Macronectes giganteus*) by the fact that *D. exulans* at all ages has the underwing white with a black tip and edging, whereas all dark phases of *M. giganteus* have the underwings dark, not white. Otherwise both are very dark on the upperparts and show no white.

[*D. regia.*] One all day. Bill pink; white tail with very slight black tip (Plate VIII, figs. 9 and 10).

Sept. 14, 1910.—40° 58′ S., 34° 41′ E., South-East of Cape Colony. [*D. exulans.*] Seven or eight fully adult ; no younger birds seen.

[*D. regia.*] In the afternoon at least three turned up. All uniformly marked, apparently pure white over the back and wings to the second joint. Several of the large *Diomedea* have had the scarlet mark on the side of the neck, like a red collar (Text-fig. 24).

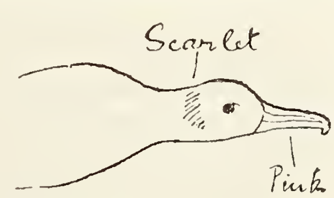

Fig. 24.—Wandering Albatross (*Diomedea exulans*). To show scarlet on head.

Sept. 15, 1910.—43° 21′ S., 41° 06′ E. [*D. exulans.*] One adult individual turned up at 3 p.m.

[*D. regia.*] Afternoon 3 p.m., rain and mist continued all day and horizon became even shorter. Sea fairly moderate, but swell quite big at times, 15 to 18 feet furrow to top. One individual which had the scarlet mark on the side of its neck quite distinctly.

Sept. 16, 1910.—47° 54′ S., 54° 57′ E. [*D. regia.*] One only, very white on the wings and with reddish mark on the side of the neck (Plate VIII, fig. 2).

[*D. exulans.*] One adult.

Sept. 20, 1910.—45° 47′ S., 77° 43′ E. [*D. regia.*] Three or four. One bird looks as though it might be *D. chionoptera,* so much white is appearing on the metacarpal coverts. Another one looks as though a typical *exulans* was just becoming a *regia,* for the white patch is still distinct but just joining up with the whiteness spreading on to the wing from the body.

[*D. exulans.*] Two or three adults, no young. One of the adults has two patches of white on each wing (Plate VIII, fig. 5).

Sept. 21, 1910.—46° 07′ S., 85° 14′ E. The one individual noted yesterday was with us, and no other. This one had two white spots on each wing.

Sept. 21, 1910.—46° 07′ S., 85° 14′ E. [*D. regia.*] One only, and this the one noted yesterday as being like *D. exulans* turning into *D. regia.* Two others turned up late in afternoon.

[*D. exulans.*] The one individual, noted yesterday, was with us and no other. This one had two white spots on each wing.

Sept. 23, 1910.—46° 59′ S., 100° 37′ E. [*D. regia.*] Two individuals, one looking as though it was changing from *D. exulans* to *D. regia.* The same bird as yesterday.

Sept. 24, 1910.—46° 49′ S., 108° 27′ E., South-west of Cape Leeuwin, S.W. Australia.) [*D. regia.*] One individual. Heavy snowstorms in the forenoon seem to have caused every bird to lose the ship, but about ten minutes after the storms cleared, though not one bird was in sight, they began to appear in the far distance of the wake, first a shearwater or two, then a few whale-birds and then a Cape Pigeon. Some half-hour later the Albatrosses turned up.

Sept. 26, 1910.—45° 58′ S., 123° 57′ E. [*D. exulans.*] Immature only (Plate VIII, figs. 1 and 8.)

Sept. 26, 1910.—43° 48′ S., 146° 01′ E. Counted twenty Albatrosses.

Sept. 29, 1910.—43° 48′ S., 146° 01′ E. Counted twenty Albatrosses. [*D. regia.*] One or two. [*D. exulans.*] A number—adult and various immature stages—one brown all over except underwings.

Judging from the material available in the British Museum, the following four outstanding phases can be recognised in the evolution of the plumage from nestling to adult in *Diomedea exulans ;* and it is to be noted that this sequence seems to obtain in a series of *D. exulans* from whatever locality it may have been obtained.

(*a*) *Nestling.*—Covered uniformly with a brownish-grey down which is lighter beneath.

(*b*) *Juvenile.*—Top of head brownish (distinct cap) ; forehead, sides of face, chin, throat and front of neck white ; back of neck and mantle with feathers tipped with pale brown ; rump and upper tail coverts brown ; tail dark brown ; underparts dirty pale brownish, tips of feathers faintly vermiculated with brown, breast feathers darker ; wings, above dark brown, primaries brown : under wing-coverts white. A stage antecedent to this is probably more uniformly brown.

(*c*) *Immature or subadult.*—Top of head dark brown to brownish (distinct cap) ; forehead, sides of face and throat white ; feathers of back of neck fringed with brown ;

mantle, rump, upper and under tail-coverts and breast with distal ends of feathers closely vermiculated with brownish; wings as in (*b*) but darker; tail brown. This phase passes on to an older stage in which the vermiculations of the upper parts become paler and less pronounced, while the head-cap is lost, and the bases of the tail-feathers and primaries show white on the inner web. An example may be seen in the British Museum collection which is intermediate between (*c*) and the next phase (*d*).

(*d*) *Adult or Aged.*—This may be briefly described as the all-white stage, in which the entire head, neck and upper and lower parts of the body and tail are pure white, the upper wing-coverts and scapulars are faintly—or not at all—vermiculated with brownish and the median and greater wing-coverts and scapulars are broadly tipped with dark brown. It is to be noted that this last phase has been mistaken in the past for a distinct species known as *D. chionoptera,* originally described by Salvin from Kerguelen.

There would appear to be nothing in Hall's description (*Ibis,* 1900, p. 12) of a colony of Kerguelen birds to lead us to suppose that the phases of plumage passed through by them were not closely identical with those described above as characterising *D. exulans;* indeed Hall distinctly states that he observed sitting birds in three stages of plumage.

Moreover, Mr. L. Harrison Matthews, in his paper on the Birds of South Georgia ("Discovery" Reports, vol. i, p. 564), writes as follows: "That the two species *Diomedea chionoptera* and *D. exulans* are identical is proved by the fact that the writer has frequently seen birds of each type pairing together." He reproduces photographs on Plate XLIX, figs. 1, 2, 3, 4, to substantiate his contention.

Although we are convinced that the so-called *D. chionoptera* is merely the most adult phase of *D. exulans,* the name *chionoptera* will have to be applied to the Kerguelen bird in the event of that bird proving in the future to be subspecifically different from the topotypical bird (South Altantic).

It is to be noted that we have not been able to substantiate the above series of plumage sequences characteristic of *D. exulans* by evidence of *actual moulting* feathers. Until this has been done it might be maintained by some that the series of plumage phases described above although apparently correlated with the age of the bird are in reality polychromatic phases similar to what occurs in *Macronectes.*

With Mr. Harrison Matthews's reference of the Royal Albatross (*D. epomophora* =*regia*) to the *exulans* species, we are, however, in complete disagreement. Indeed, specimens in the British Museum collection definitely and conclusively prove that this species is genetically distinct from *D. exulans.* These specimens are represented by two birds from Campbell Island (New Zealand), which are moulting from the down into the first juvenile phase of plumage. The down is pure white and the bird moults direct from the down into a plumage which can barely be distinguished from that of the adult, and which in appearance somewhat corresponds to the most adult plumage phase of *D. exulans.* Thus in *D. epomophora* (=*regia, auctorum*) we get, so to speak, a short-

circuiting or suppression of all the juvenile, immature or subadult phases of plumage characteristic of *D. exulans*. As we have noted below we have strong reason to suspect that this suppression occurs in the case of *Thalassarche chlororhynchos* but not in *Thalassarche chrysostoma*.

MEASUREMENTS OF *DIOMEDEA EXULANS*

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of Culmen.	Greatest depth of Culmen.	Tarsus.
1914.3.8.21 ..	♂	1.i.14	South Georgia	P. Stammwitz ..	168	53	119
1922.12.6.8 ..	♂	31.xii.21	,, ,, ...	Wilkins	166	51	118
1914.2.9.1. ..	—	—	600 miles W. of Cape Horn ..	R. A. Batt ..	173	50	122
1905.12.31.216	imm. ♂	22.ix.01	30° 10′ S., 13° 40′ W.	E. A. Wilson ..	150	47	120
1892.11.16.1 ..	—	—	Cape Seas	Capt. T. Harry	160	51	121
1916.6.20.104 ..	imm. ♂	21.x.10	44° 30′ S., 155° E.	.. .. ..	143	48	111
1903.3.20.1 ..	imm.	—	Antipodes Is.	Lt. K. Dixon ..	157	48	117
1891.5.20.872 ..	♂	iv.75	New Zealand	Hume Coll. ..	170	51	122
1905.12.30.404	imm. ♂	15.i.03	Antipodes Is.	Capt. Hutton ..	149	46	115
1886.2.1.31 ..	imm. ♀	—	29° 45′ S., 57′ 29′ E.	Lord Crawford ..	162	45	120
1886.2.1.32 ..	imm.	12.x.	39° 41′ S., 32° 19′ E.	,, ,, ..	170	50	124
1913.12.26.5 ..	♂ ?	1910	"On the way to Australia" ..	R. McConnell ..	165	49	120
1880.12.10.1 ..	—	—	"On the way to New Zealand"	Sturgeon ..	168	54	120
1880.11.18.683	♂	11.xi.75	37° 23′ S., 83° 1′ W.	"Challenger" ..	156	47	—
1880.11.18.682	♂	i.74	Kerguelen (type of *chionoptera*)	,, ..	166	53	126
1841.748 ..	♂	—	,, ...	Antarctic Exped.	170	54	126
1909.11.16.18 ..	♂	13.xii.07	Possession Is., Crozets	Dr. Collett ..	169	53	122
1909,11.16.17 ..	—	13.xii.07	,, ,, ...	,,	163	51	120
1880.11.18.684	—	xii.73	Marion Is.	.. .. ..	174	55	118
1901.1.7.60 ..	imm. ♀	29.x.98	44° 26′ S., 37° E., near Prince Edward Is.	Hanson ..	160	49	116
1901.2.5.4 ..	♂	24.x.98	42° 23′ S., 20° 32′ E., S. of Cape	,, ..	176	52	124

31. *Diomedea epomophora* (Royal Albatross). Plate VIII, figs. 10 and 11.

Diomedea epomophora Lesson, Annales Sci. Nat. Paris, vi, p. 95, 1825 (Campbell Is.); *Diomedea regia* Buller, Trans. New Zealand Inst. xxiii, p. 234, 1891 (Campbell Is.); Salvin, Cat. Birds Brit. Mus. xxv., p. 443, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 110, 1907; *Diomedea epomophora maccormicki* Mathews, "Birds of Australia," ii, p. 261, 1912 (Auckland Is.).

The following notes in Commander Pennell's diary undoubtedly refer to the Royal Albatross:—

July 11, 1911.—42° 06′ S., 175° 13′ E. Absolutely snow-white above and below except the tips of the long primaries on the upperside, which are black. The purest white Albatross I have seen. Bill flesh-colour.

Aug. 6, 1911.—34° 08′ S., 171° 53′ E. (West of West I., Three Kings.) Two settled on the water close to the ship, feeding, and remained a long time. The Mollymauks were afraid of them and never attempted to dispute the possession of food with them as they did continuously amongst themselves.

Sept. 6, 1911.—34° 25′ S., 172° 10′ E. (Off Three Kings Is.) One fine specimen.

We have already expressed our opinion when discussing *D. exulans* that this last albatross is genetically distinct from the Royal Albatross, *D. epomophora*. The following description of plumage is based on material in the British Museum:—

(*a*) *Nestling.*—Covered with pure white down.

(*b*) *Juvenile.*—(With down still attached to feathers "coming through"): general coloration white—dorsum white with no dark vermiculations, but scapular and inter-

scapular feathers with dark terminal or subterminal bands or "drops"; entire head and neck pure white; tail nearly pure white but with a certain amount of vermiculation; first primary with distal half dark.

(*c*) *Adult.*—Similar to juvenile but with terminal and subterminal bands of scapulars and interscapulars less heavy; first primary with distal third dark.

MEASUREMENTS OF *DIOMEDEA EPOMORPHORA.*

Reg. No.	Sex.	Date.	Locality.	How acquired.	Length of bill.	Greatest depth of culmen.	Tarsus.	Notes.
1900.2.22.3 ..	—	20.x.1899	Campbell Is. Sitting on nest.	.. .. ..	183	46	132	
1895.3.1.1. ..	—	24.iv.1894	New Zealand ..	Sutcliff	185	53	131	
1891.6.16.5 ..	—	20.xi.1840	Endeby Is. Auckland Is.	McCormick ..	168	46	123	
1891.6.16.4 ..	—	30.xi.1840	,, ,,	,, ..	179	54	130	
1901.1.7.62 ..	Juv.	4.x.1899	Campbell Is. ..	"Southern Cross"	180	51	130	
1901.1.7.63 ..	Juv.	—	,, ..	,, ,,	170	46	122	
1901.1.7.61 ..	Juv.	7.x.1899	,,	,, ,,	172	45	120	
Tring	♀	15.vii.1827	36° S., 52° 30′ W. ..	Buenos Museum	172	50	123	
,, ...	♂	—	New Zealand ..	Buller Coll. ..	184	55	130	
,, ...	♂	—	,, ..	,, ..	171	50	117	
,, ...	—	—	South Pacific, "Off Australia."	.. .. ..	172	54	124	
,, ...	♀	—	New Zealand (type of *D. e. rothschildi*) *	.. .. ..	172	51	115	
,, ...	♂	—	No locality ..	Buller Coll. No. 8	176	51	119	
,, ...	♀	—	,, ..	,, No. 9	174	51	119	
,, ...	♀	—	New Zealand ..	,, D	169	48	114	
,, ...	♂	—	,, ..	,, C ..	173	53	121	
,, ...	♂	12.vii.1827	35° 41′ S., 53° W.	,, ..	178	53	121	Mottled tail.
,, ...	♂	13.iii.1875	New Zealand—Melbourne.	Von Hugel ..	162	50	111	Upper parts brown; throat white; breast brown; belly paler; tail and wings brown.
,, ...	♂	13.iii.1875	,, ,,	,, ,, ..	172	52	139	Coloration as above.

* We think this is *not* an *exulans.*

32. *Thalassarche melanophris* (Black-browed Mollymauk). Plates IX; XIV, fig. 6, and XV, figs. 4 and 5.

Diomedea melanophris Temminck et Laugier, Planch. Color. d'Ois, v, No. 456, pl. 115, 1828 (Cape of Good Hope); *Diomedea melanophrys* Salvin, Cat. Birds Brit. Mus. xxv, p. 447, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 111, 1907; *Thalassarche melanophris impavida* Mathews, "Birds of Australia," ii, p. 267, 1912 (Tasmania).

MATERIAL OBTAINED

No. 43.	♂ 22.x.1910.	44° 25′ S., 160° E.	Bill yellow with orange tip; legs, toes, and webs pale greyish flesh-colour.
No. 45.	♂ ditto.	ditto.	ditto.
No. 46.	♂ ditto.	ditto.	ditto.

Systematic Notes.—The three specimens brought back by the Expedition should be, according to Mathews, *T. m. impavida*, inhabiting the New Zealand and Australian Seas. This race is said by the describer to be distinguished from the birds breeding on

Kerguelen by "its shorter bill, the more pronounced black in front, above and behind the eye, and the greyish wash over the lores."

In regard to size the birds from the Australian—New Zealand area, as will be seen from the comparative table of measurements, average smaller, and if we take the range of the length of the bill of the birds from the two areas we find those from Kerguelen are 114 mm. to 120 mm., while the others run smaller, 106 to 119 mm.

None of the Kerguelen specimens has the greyish wash on the lores which is found in a certain number of the Australian—New Zealand examples, while the black in front, over, and behind the eye is on the whole more distinct in the latter than in the former. The colour of the bill does not seem to differ, but the feet of Kerguelen birds are given as fleshy-red with webs of the same colour, while those from Australia and New Zealand are recorded as flesh-grey, a light grey or greyish-flesh. We are not, however, prepared to place much reliance on these colour differences, since they may be connected with age and sex, and until further specimens of different ages are available it does not appear desirable to keep these forms separate.

The original specimen to which the name *melanophris* was given by Temminck came from the Cape of Good Hope, and Mathews considers that the typical form breeds on Gough Island, Tristan da Cunha, and the Falklands, but on what grounds we do not know. There is a single skin in the British Museum and two at Tring from the Cape of Good Hope, while in the last-mentioned museum there is one specimen from the Falkland Islands, but in neither are there any birds from Gough or Tristan da Cunha.

It seems to us that the Cape specimens agree equally with the Kerguelen examples as with the single bird from the Falklands, and till a series has been compared from the last-named locality it will not be possible to decide the question.

Three skins from South Georgia in the British Museum have the longest bills of any we have measured, but the birds from Chili and Peru hardly seem to be distinguishable from the Kerguelen specimens, and the differences in the bills claimed by Mathews are not borne out by our measurements.

In regard to the colour differences there seems to be a considerable amount of individual variation.

Wilson's first entry in regard to this species is as follows :—

> *Aug.* 8, 1910.—33° 26′ S., 5° 34′ W., West of Cape Town. *Diomedea melanophrys*. Two which I saw were billing one another exactly as though they were adult and young. The adult bird has the typical yellow bill with orange tip : the other a yellow bill with a black tip.

On August 10, in 35° 27′ S., 0° 39′ E., this Albatross was again noted and it continued to be seen till August 14 when off Cape Town, under which date Wilson notes : "The Albatross settled before the heavier squalls and did not appear on the wing at those times. We came into Simon's Bay in a very squally fresh gale."

On September 11 Wilson left Cape Town in the "Corinthic" for Australia and immediately fell in with this species again, noting: "Two or three adults with yellow bill and orange tip." On the following day, in 36° 26′ S., 22° 47′ E., he remarks: "Ten or more all day. A marked difference in size of what appeared to be this bird in the distance but probably was not. One bird—a young of *D. melanophrys ?*—had a pure white head and a pale yellow bill with a black tip." This Albatross was seen every day till September 29, in 43° 48′ S., 146° 01′ E., and all appear to have been adults, since Wilson in nearly every case notes: "yellow bill and orange tip."

Pennell, in the "Terra Nova" during the voyage from the Cape to Melbourne, noted five of these birds on September 21, S.E. Cape of Good Hope, and again on September 27, when he remarks: "Many; they settle in the water when things are thrown overboard and then, from that position, dive completely under after them if necessary."

After the "Terra Nova" left New Zealand on her southward voyage this species was again met with, first on November 30 off South Island when several adults were recorded, up to December 7, in 61° 22′ S., 179° 56′ E. On all occasions except two adults were noted, but on two occasions young birds with dark bills were also seen, viz:—

> *Dec.* 3, 1910.—"Again very busy with the ship in a heavy gale, but saw adults all with orange-yellow bill. Very abundant and very bold in coming for food under the counter."
>
> *December* 4, 1910.—"Several adults with orange bills and one younger one with dusky yellow bill and blackish tip."

On February 13, 1911, Pennell in 71° 13′ S., 171° 15′ E., some fifty miles N.W. of Cape Adare, notes in the zoological log of the "Terra Nova" "a few seen." Then throughout the return voyage to New Zealand he records this bird daily in varying numbers.

Under the date of March 15 (58° 25′ S., 161° 22′ E.) he records: "Nine at one time, one having a curious dark bill and almost black unguis. It dives into and under water with three-quarters expanded wings, coming up with the wings still half-open." On March 18, in 56° 28′ S., 162° 58′ E., the first specimen in the list was captured and full details were taken of all the soft parts: "One caught (No. A), legs and webs lilac, tinged with red; toenails white, iris light golden. Culmen yellowish-horn at the base gradually becoming pinker towards the unguis and end of the mandible, which are pink. The thin line of skin where the bill joins the feathers of the head is black. On the side of the lower mandible there is a small strip of pink skin: inside of the mouth and skin of the pouch below the mandible is dull lilac-colour. The gullet contained crustaceans of the Order *Euphausiacea* and a lot of garbage thrown over the ship, including a mass of paper. Many of these birds are rather quarrelsome (or perhaps peevish would be a better expression). When food is thrown over they settle on the water, keeping their wings half-expanded for a little till comfortably settled down, and peck at any others that come near, though I have never seen two really fight."

MEASUREMENTS OF *THALASSARCHE MELANOPHRIS*

AUSTRALIAN—NEW ZEALAND AREA

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of Culmen.	Depth of Culmen.	Tarsus.	Wing.	Notes.
Tring ..	—		New Zealand	*ex* Buller Collection ..	119	36	81	510*	
1844.9.3.58 ..			South Australia ..	Sir George Grey	118	37	85	—	Supra-orbital distinct, but not very marked.
Tring ..	♀	3.xi.1897	Off Cape Otaway, S. Australia.	R. Hall [C.]	118	33	85	523	
Tring ..	♀	21.viii.1913	Broken Bay, N.S. Wales	*ex* Mathews Collection	115	37	85	—	Feet light grey, darker edges; iris yellowish-white; bill lemon-yellow orange.
1891.5.20.873		x.1874 ..	New Zealand	*ex* Hume Collection ..	115	35	86	513*	Supra-orbital distinct, extending slightly over lorex.
	♂	17.vii.1889	Tasmania		114	35	82	305	
1891.5.20.873	♂	11.vii.1847	Off entrance to Bass Straits	J. MacGillivray [C.] ..	114	35	82	508*	Supra-orbital indistinct behind.
1880.11.18.687	♂	8.vii.1874	40° 16′ S., 177° E. ..	" Challenger " Exped. ..	113	—	83	518	Supra-orbital distinct, extending on to lores. Moulting on mantle.
Tring ..	♂	20.vii.1913	Broken Bay, N.S. Wales	*ex* Mathews Collection	112	34	84	485	
Tring ..			New Zealand	*ex* Buller Collection ..	113	—	80	—	
1905.12.30.399	♂	10.iii.1904	58° S., 176° E.	"Discovery" Exped., E. A. Wilson [C.]	112	37	83	514	Supra-orbital dark behind and in front, slightly extending over the lores, Worn; moulting soft parts as in 1905, 12.30.402.
1905.12.30.460	♂	29.xii.1901	56° S., 170° E.	,, ,, ,,	112	35	83	496*	
1905.12.30.402	♀	29.xii.1901	56° 43′ S., 170° 37′ E. ..	,, ,, ,,	112	34	86	506	Iris hazel-brown; bill yellow, tip reddish; legs, feet and webs flesh-grey, nails horn. Supra-orbital distinct in front, extending over the whole of the lores. Fresh plumage.
1916.6.20.94 ..	♂	22.x.1910	44° 25′ S., 160° E. ..	" Terra Nova," A. C. Garrard.	111	36	83	—	Supra-orbital very grey behind and in front extending over lores. Soft parts as in 1916.6.20.92.
Tring ..	♂	1.vii.1913	Broken Bay, N.S. Wales	*ex* Mathews Collection	111	34	83	505	
,,	♂	5.viii.1913	,, ,, ,,	,, ,, ,,	111	33	84	510	
,, ..	♀	20.vi.1912	,, ,, ,,	,, ,, ,,	111	34	80	—	
1893.3.20.2 ..	—		Campbell Is.	Lt. Kenneth Dixon, R.N.	110	34	80	484	Supra-orbital distinct behind and in front of eye, but not extending on to lores. Bill yellowish with orange tip, legs, toes and web pale greyish flesh-colour.
1916.6.20.93 ..	♂	22.x.1910	44° 25′ S., 160° E. ..	"Terra Nova" Exped., A. C. Garrard [C.]	110	35	81	507	Supra-orbital very grey behind and in front extending on to lores.
1905.12.30.407	♀	xii.1893 ..	56° S., 172′ E. ..	"Morning" Relief Exped., A. G. Davidson [C.]	109	35	79	501	Supra-orbital distinct and extending on to lores. Bill yellow with orange tip; legs and toes pale greyish flesh-colour.

1916.6.20.92 ..	♂	22.x.1910	44° 25′ S. 160° E. ..	"Terra Nova" Exped., A. C. Garrard [C.]	109	37	85	523	Supra-orbital distinct behind and in front, hardly extending on to lores.
Tring ..	♀		Campbell Is.		104	31	75	690*	
1905.12.30.401	♀	29.xii.1901	56° 3′ S., 170° E. ..	"Discovery" Exped., E. A. Wilson [C.]	106	32	76	494*	Iris hazel-brown; bill yellow-ochre-brown, tip black; legs, feet, and webs flesh-grey, nails yellowish horn. Supra-orbital very dark behind and in front extending over the lores. Slightly worn plumage.
Tring ..	♂	20.vii.1901	Broken Bay, N.S. Wales	*ex* Mathews Collection	99	34	76	480	
				CAPE OF GOOD HOPE					
1913.12.26–6..			Cape–Australia. ..		122	37	87	543	Supra-ocular very distinct, but no grey on lores.
1842.12.21.8 ..			Cape	Townsend	115	35·5	86	520	Supra-ocular only showing in front of eye.
Tring ..			Dyer Is., Cape		113	36	90	—	
,, ..			Robbin Is., Cape ..	Gerrard & Sons, *ex* Hamlyn	112	33	86	510*	
				KERGUELEN AREA					
Tring ..	♀	3.ii.1908 ..	Greenland Harbour, Kerguelen.	R. Hall [C.]	120	36	82	515*	
1880.11.18.685	♂	i. 1874 ..	Kerguelen	"Challenger" Exped. ..	119	37	86	523*	Supra-orbital very distinct both behind and in front.
1880.11.18.686	♀	i.1874 ..	Kerguelen	,, ,, ..	119	38	86	523*	Supra-ocular intermediate between 751 and 685. Iris greyish-brown, bill yellow, tip red, feet fleshy-red, the webs of the same colour.
1901.1.7.27 ..	♂	13.x.1898	33° 37′ S., 9° 54′ E. ..	"Southern Cross" Exped. N. Hanson [C.]	119	38	86	523*	Supra-ocular practically absent except a little behind and in front. Not moulting.
1901.1.7.25 ..	♀	6.xi.1898	44° 20′ S., 68° 28′ E. ..	,, ,, ,,	118	34	83	527	Supra-ocular extending well behind and faintly on to the back of the head. Iris greyish-brown; bill yellow, tip red; feet fleshy-red, the webs of the same colour. Not moulting.
1901.1.7.26 ..	♀	7.xi.1898	44° 23′ S., 72° 5′ E. ..	,, ,, ,,	116	34·5	84	522	Soft parts as above. Moulting on mantle. Supra-ocular distinct in front and behind, but not extending far back.
Tring ..	♀	7.xi.1898	44° 23′ S., 72° 5′ E. ..	,, ,, ,,	115	25	82	529	
1841.751 ..		5.vii.1840	Kerguelen	"Erebus" and "Terror" Exped.	114	38	84	512*	Supra-orbital absent except very faintly in front of eye.

* Denotes tip of primaries worn.

MEASUREMENTS OF *THALASSARCHE MELANOPHRIS*—*continued*

KERGUELEN AREA—*continued*

Reg. No.	Sex	Date.	Locality.	How obtained.	Length of Culmen.	Depth of Culmen.	Tarsus.	Wing.	Notes.
1914.3.8.22 ..	♀	13.i.1914	South Georgia	P. Stammwitz	122·5	39	88	522	Moulting on mantle. Supra-orbital distinct especially behind eye and continuing towards nape.
1914.3.8.23 ..	♂	24.x.1913	"		122	39	88	540	Ditto, ditto.
1922.12.6.14 ..	♀	31.xii.1921	"	"Quest" Exped., H. Wilkins [C.]	122	34	85	510*	Supra-orbital distinct and continuing some way behind eye. Bill yellowish to horn; iris brown: feet yellowish.
FALKLAND ISLANDS									
Tring ..			Falkland Is.		119	36	84	490*	
CHILI AND PERU									
Tring ..	♂	20.v.1912	Lobos de Tierra Is., W. Peru.		119	36	88	462	
1922.2.10.698			Valparaiso	*ex* Berkley James Collection.	119	38	86	526*	Supra-orbital absent behind and only just showing in front.
1891.9.9.180 ..			Bay of Tarapaca, N. Chili	" " "	118	33	84	530	Supra-ocular distinct in front and fainter behind.
1903.12.30.204	♂	17.ii.1903	Valparaiso	"Vahalla" Expd., M. J. Nicoll [C.]	118	36	80	500*	Supra-orbital practically absent. Bill black; tarsus and toes black with olive-brown wash; iris hazel, very worn plumage.
1913.11.10.13	♀	21.vi.1912	West Peru	H. O. Forbes [C.] ..	118	36	83	—	Supra-ocular very distinct over eye, but not extending much in front or behind. Moulting.
1888.5.18.161			Talcahuano Bay, N. Chili	A. Markham [C.] ..	116	34	82	508*	Moulting on mantle. Supra-orbital fairly distinct in front, fainter behind.
1892.2.10.400			Valparaiso	*ex* Berkley James Collection.	116	36	83	—	Supra-ocular faint in front and almost absent behind. Moulting on wings and mantle.
1880.8.3.6 ..	♂	13.viii.1879	"	H.M.S. "Alert," Coppinger [C.]	114	35	87	513	Bill grey with dark tip, feet light grey; iris brown.
1891.9.9.181 ..	♀	24.x.1890	Corral.	*ex* Berkley James Collection.	110	35	86	510	Supra-ocular distinct in front fainter behind.

* Denotes tip of primaries worn.

33. *Thalassarche chrysostoma* (Blue-headed Mollymauk). Plates X; XIV, fig. 5; XV, fig. 1.

Diomedea chrysostoma Forster, Mem. Math. Phys. (Paris), x, pl. 14, p. 571, 1785 (Cape Seas), *Diomedea culminata* Gould, Proc. Zool. Soc., p. 107, 1843 (Bass Strait); *Thalassogeron culminatus* Salvin, Cat. Birds Brit. Mus. xxv, p. 451, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 113, 1907; *Diomedea culminata mathewsi* Rothschild, Bull. Brit. Orn. Club, xxix, p. 70, 1912 (Campbell Island); *Thalassogeron chrysostoma harterti* Mathews, "Birds of Australia," ii, p. 280, 1912 (Kerguelen Island); *Thalassogeron chrysostoma alexanderi* Mathews, Austral. Av. Rec. iii, p. 55, 1916 (West Australia).

MATERIAL OBTAINED

No. 13.	♂ 27.iii.1912.	52° 11′ S., 167° 25′ E.		Legs and feet white tinged with purple, legs rather darker. Inside of mouth and bill white, fleshy parts pale violet, unguis pink fading into white at the tip: culmen and lower part of mandible very light yellow: iris brown.
No. 14.	♀	ditto.	ditto.	Same as above, but the bill of rather a deeper colour throughout and the inside of the bill the same colour as the culmen, *i.e.* yellow not white.
No. 15.	♀	ditto.	ditto.	,, ,,

When on the voyage from Cape Town to Melbourne in the S.S. "Corinthic," Wilson on several occasions observed this species and made a coloured sketch of two individuals. The entries in his diary are as follows:—

Sept. 14, 1910.—40° 58′ S., 34° 41′ E., South-east of Cape Colony. Grey head, black bill with broad yellow culmen and tip, and orange-yellow stripe on the under mandible. Under-wing with a broad black margin in front and narrow one behind. (Coloured Plate XIV, fig. 5.)

Sept. 19, 1910.—45° 37′ S., 70° 06′ E., South of Kerguelen Island. One adult with a broad yellow band along the top of the culmen and a yellow and orange line along the lower bill, with a turn up at the base, the rest of the bill black. Head grey all over. (Coloured Plate XIV, fig. 5.)

Sept. 23, 1910.—46° 59′ S., 100° 37′ E. Two individuals.

Sept. 24, 1910.—46° 49′ S., 108° 27′ E., South-west of Cape Leeuwin, S.W. Australia. Two individuals.

Sept. 27, 1910.—45° 18′ S., 131° 27′ E. Three individuals.

Commander Pennell also noted this Albatross after the "Terra Nova" left the Cape on September 22nd and 23rd, in 38° 58′ S., 80° 37′ E., and 39° 15′ S., 83° 33′ E., and notes as follows: "Two seen, entire head and neck grey, top and bottom of bill yellow."

On the "Terra Nova's" return voyage from the south this Albatross was again met with in 61° 16′ S., 163° 11′ E., on March 11, 1911, and almost daily till New Zealand was reached. On March 17, 56° 14′ S., 163° 48′ E., Commander Pennell has the following entry: "Two came quite close under the stern many times. Bill black; culminicorn yellow; unguis reddish-yellow, underside of the lower mandible yellow; feet flesh-colour. Head and neck, including the crown, delicate grey."

MEASUREMENTS OF *THALASSARCHE CHRYSOSTOMA*

THE CAPE AREA

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of Culmen.	Greatest Depth of Culmen.	Tarsus.	Wing.	Notes.
1901.1.7.67 ..	♂	24.x.1898	42° 23′ S., 20° 32′ E. ..	" Southern Cross " Exped., N. Hanson.	123	35	88	522+	
1901.1.7.66 ..	♂	24.x.1898	42° 23′ S., 20° 32′ E. ..	" Southern Cross " Exped., N. Hanson [C.]	108	33	79	490+	
Tring ..	♀	23.5.1884	Table Bay, Cape Colony	E. R. Hawes [C.], *ex* Bannerman.	107	29	83	490	Eye stripe distinct in front of eye ; top of head greyish ; cheeks white ; bill culminicorn dark brown.

MARION ISLAND, KERGUELEN AND AMSTERDAM ISLANDS AREA

Reg. No.	Sex.	Date.	Locality.	How obtained.	Length of Culmen.	Greatest Depth of Culmen.	Tarsus.	Wing.	Notes.
Tring ..	♂	12.xi.1899	36° S., 33° E.	R. Hall [C.]	113	34	88	530	Head and cheeks grey, bill pale on culminicorn ; eyes dark ; feet bluish.
1901.1.7.68 ..	♂ ad.	6.xi.1899	44° 20′ S., 68° 28′ E. ..	" Southern Cross " Exped., N. Hanson [C.]	112	34	84	500	
Tring ..	♂	8.x.1902	46° 52′ S., 85° E. ..	R. G. England	111	33	86	512+	Head grey, also cheeks and throat ; bill dark all over. Type of *T. c. harterti*.
Tring ..	♂	6.xi.1898	44° 20″ S., 68° 28′ E. ..	" Southern Cross " Expd., N. Hanson [C.]	108	33	81	488	Head, cheeks, and throat grey, bill pale on culminicorn.
1901.1.7.64 ..	♂ im.	9.xi.1898	45° 9′ S., 77° 13′ E. ..	" " "	108	32	81	513+	
Tring ..	♀ vix.ad.	7.xi.1898	44° 23′ S., 72° 5′ E. ..	" " "	112 damaged	33	84	516	Head whitish on top ; eye spot distinct; cheeks and throat white ; neck greyish ; culminicorn intermediate.
1901.1.7.65 ..	♀ im.	9.xi.1898	45° 9′ S., 77° 13′ E. ..	" " "	104	31	78	494	
1891.5.20.374	—		Kerguelen	*ex* Hume Coll.	110	33	85	495+	
	im. ?	5.vi.1847	36° 50′ S., 95° 50′ E. ..	H.M.S. " Rattlesnake," S. MacGillivray [C.] ..	109	33	83	516+	
Tring ..	ad.	27.xi.1890	45°, 80° E.	*ex* Dresser Coll.	108	34	87	450	Head and cheeks grey, bill pale on culminicorn ; eyes dark ; feet bluish.

AUSTRALIA—NEW ZEALAND AREA

Tring [122*a*]	♂		New Zealand [No. 122*a*]		118	33	87	500	Head, cheeks and throat grey; culminicorn pale.
,, ..	♂	30.vii.1903	Snares Is.	M. Hutton [C.]	118	33	87	500	Top of head pale, cheeks grey, eye stripe distinct; culminicorn pale.
,, ..	♀ imm.	25.ii.1903	Campbell Is.		115	34	86	509	Head, neck, cheeks grey; bill slightly pale on culminicorn.
			New Zealand		113	34	82	495+	Head cheeks and throat grey; culminicorn pale.
	imm.			" Morning " Relief Exped.	113	45	88	527	
1841.12.89 ..	imm.	30.viii.1839	Off Tasmania	J. Gould	111	33	89	532	
Tring ..	♀ imm.	25.ii.1903	Campbell Is.		111	35	89	496+	Top of head light, neck grey; cheeks white; eye spot distinct; bill dark all over. Type of *mathewsi*.
1905.12.30.403	♀	29.xii.1901	56° 54′ S., 170° E. ..	" Discovery " Exped. ..	111	33	80	482	
1916.6.20.87	♀	27.iii.1912	52° 11′ S., 167° 25′ E.	" Terra Nova " Exped. ..	110	34	83	484	
1916.6.20.88	♀	27.iii.1912	52° 11′ S., 167° 25′ E.	,, ,, ..	110	33	83	492	
1900.2.22.4 ..		22.xi.1899	100 miles S. of Campbell Is.	H.M.S. " Ringdove " ..	110	35	85	514	
Tring ..	♀ imm.	25.ii.1903	Campbell Is.		109	34	88	527	Lighter on top of head, neck grey, cheeks white; eye spot distinct; culminicorn dark.
1916.6.20.86	♂	27.iii.1912	52° 11′. S., 167° 25′ E.	" Terra Nova " Exped. ..	109	34	87	489+	
	imm.	?	?	" Morning " Relief Exped.	109	44	88	507+	
1841.1290 ..	ad.		Australian Seas ..	J. Gould	104	41	80	490	
Tring ..	♂ imm.	7.vii.1902	Mandurah	*ex* Mathews' Coll., Inspector Eaton [C.]	103	33	82	515	Head and cheeks grey, throat paler; culminicorn dark. Type of *alexanderi*.

SOUTH GEORGIA

1922.12.6.16	♂	30.xii.1921	South Georgia	" Quest " Exped., G. H. Wilkins [C.]	120	48	88	518
1922.12.6.17	♂	30.xii.1921	,, ...	,, ,, ,,	117	47	89	532
1922.12.6.19	♂	30.xii.1921	,,	,, ,, ,,	116	46	92	547
Tring ..	♂	30.xii.1921	,, ...	,, ,, ,,	114	—	—	—
1922.12.6.15	♂	30.xii.1921	,, ...	,, ,, ,,	107	43	—	—
1922.12.6.20	♀	30.xii.1921	,, ...	,, ,, ,,	117	47	—	—
1922.12.6.18	♀	30.xii.1921	,, ...	,, ,, ,,	115	42	—	—
1922.12.6.21	—	30.xii.1921	,, ...	,, ,, ,,	112	42	—	—

Apparently it was observed continuously from the above position till 57° 30′ S., 174° 29′ E., was reached on March 22.

During the second voyage south this species was noted between December 18, 49° 40′ S., 171° 45′ E., and December 22, 1911, 57° 30′ S., 174° 29′ E., and on the return it was observed from March 9, in 71° 32′ S., 173° 21′ E., till March 27, in 52° 16′ S., 167° 31′ E., when the three specimens listed above were captured.

On the third voyage south this Albatross was first seen in 51° 22′ S., 179° 19′ W., on December 18, 1912, and continuously till 59° 28′ S., 169° 33′ W., was reached on December 24. As the ship approached New Zealand on the last voyage examples were noted on February 2 and 3, in 62° 09′ S., 158° 52′ E.; on the following day and again on February 6, in 54° 22′ S., 164° 49′ E.

During the homeward voyage from New Zealand the zoological log of the "Terra Nova" contains records of this Albatross seen from 53° 52′ S., 171′ 23′ W., on March 18, almost continuously till April 11, in 56° 42′ S., 68° 11′ W.

As far as the material (twenty-three specimens) available in the British Museum enables us to judge, the following notes may possibly represent the sequence of plumage phases correlated with the evolution of this species from chick to adult:—

(1) *Chick in down.*—Pearly or pale sooty-grey above, lighter below; bill black.
(2) *Juvenile.*—Entire head, nape, neck and mantle greyish-brown or sooty-brown; throat lighter; underparts and upper tail coverts white; culminicorn black, blackish horn, or horn-coloured showing tinge of yellowish.
(3) *Older phase.*—Top of head, sides of face and throat white; nape back of neck and mantle sooty-grey; bill as regards culminicorn and lower edge of mandible showing distinct signs of colour proper to adult phase.
(4) *Adult.*—Head suffused with bluish slate, or slaty-blue; throat lighter; back of neck dirty-white; underparts white; mantle brownish-grey; bill-culminicorn and lower edge of mandible yellow-orange.

As will be seen by the synonymy the birds of this species have been divided into a number of races.

After a careful examination of the material in the British Museum and Tring collections we are unable at present to recognise any of these, chiefly from the want of adult material from the areas east of the Cape of Good Hope and young birds from South Georgia.

T. c. alexanderi was separated by Mathews from *T. c. culminatus* (*chrysostoma*) on account of the smaller bill and yellow not so pronounced. The type of this sub-species, in the Tring collection, is a young bird and certainly has a small bill which only measures 103 mm., but otherwise cannot be separated from specimens of similar age from elsewhere.

The type of *T. c. harterti* is also at Tring and is said to differ from *T. c. chrysostoma* in "its deeper, heavier bill and agreeing in the coloration of the head and neck with *T. c. mathewsi* Rothschild." In regard to the differences in the bill, all we can say is that the measurement of the bill of the type is: length 111 mm., depth in front of nostril

33 mm., whereas three birds, not adult, from the Cape Seas have bills ranging from 107–123, with a depth of from 29–35, and eight adults from S. Georgia range in length from 107 to 120, and depth from 33 to 38.

T. c. mathewsi Rothschild, is a sub-adult bird with dark bill, grey head, lighter (almost white) on top, and cheeks white ; this last character and the colour of the bill were Lord Rothschild's main reasons for separating this race. He now, however, agrees with us that none of his birds from Campbell Is. is adult, and that their separation from the typical bird is a very moot point.

See Tables, pp. 174, 175.

34. *Thalassarche chlororhynchos* (Yellow-nosed Mollymauk). Plates XIV, figs. 1–4, and XV, fig. 3.

Diomedea chlororhynchos Gmelin, Syst. Nat. i, pt. ii, p. 568, 1785 (Cape of Good Hope) ; *Thalassogeron eximius* Verrill, Trans. Connect. Acad. ix, pt. ii, p. 440, 1895 (Gough Island) ; *Thalassogeron carteri* Rothschild, Bull. Brit. Orn. Club, xiv, p. 6, 1903 (Point Cloates, N.-West Australia) ; *Thalassogeron chlororhynchus* Salvin, Cat. Birds Brit. Mus. xxv, p. 451, 1896 ; Wilson, Nat. Ant. Exped. " Discovery," N. H. ii, Aves, p. 114, 1907 ; *Diomedea bassi* Mathews, Nov. Zool. xviii, p. 206, 1912 (East Australia).

Dr. Wilson has a number of notes in his diary which refer to this species.

WESTERN AREA

Aug. 4, 1910.—30° 56′ S., 16° 48′ W., North-west of Gough Island. One about all day, pure white on the forehead, crown and throat, but with a greyish collar and cheeks. We take it to be *T. eximius* as we cannot see any trace of yellow on the lower part of the bill, though the culmen is conspicuously yellow along the whole length of its upper surface. Lt.-Commander Pennell, R.N., describes the bird as having the bill dark, yellow on top ; head and throat light grey ; back, wings, and tail black, but the tips of the wings are rather greyer ; rump and underparts white, the tips of the wings below and the tip of the tail below black.

Aug. 5, 1910.—31° 47′ S., 14° 06′ W., North of Tristan da Cunha. One about all day, yellow culmen, white forehead, not much grey. Feet yellowish flesh-colour ; black back and wings and black tail. We take this to be the Gough Island Albatross.

Aug. 8, 1910.—33° 26′ S., 5° 34′ W., West of Cape Town. *Thalassogeron* sp. ? With a grey collar, white head and dusky bill.

Aug. 9, 1910.—34° 30′ S., 2° 33′ W. Three together in the evening. *Thalassogeron* sp. inc. Wings and back black as in *Diomedea melanophrys.* Head very light grey ; under wings nearly all black, very little white indeed.

Aug. 10, 1910.—35° 27′ S., 0° 39′ E. *Thalassogeron* sp. inc. Blackish bill, white head, black eye. Added pencil note : " Surely *D. melanophrys* immature stage."

EASTERN AREA

Sept. 11, 1910, East of Cape Town. Two with the head white, the nape and sides of the neck grey, and the bill blackish-looking.

Sept. 14, 1910.—40° 58′ S., 34° 41′ E. *Diomedea* sp. Smaller than *D. melanophrys*

and with a white head but black bill, very little white under the wing; black eye. Looks like an adult bird, therefore doubt whether it is an immature of *D. melanophrys*.

Dec. 1, 1910.—50° 44′ S., 170° 38′ E., South of New Zealand. One appeared late in the evening.

Dec. 2, 1910.—52° 07′ S., 172° 11′ E., South of New Zealand. A black-billed, white-headed Albatross with a grey collar, otherwise like *D. melanophrys* immature. (The same as seen on the previous evening.)

Dec. 3, 1910.—52° 12′ S., 172° 48′ E. Grey-collared black-billed Albatross of December 2nd. One or two seen.

It should be noted that Wilson's observations in August were made when he was on the "Terra Nova" between Tristan da Cunha and the Cape, and those in September while he was proceeding in S.S. "Corinthic" from the Cape to Melbourne. Commander Pennell, who followed with the "Terra Nova," made similar observations on Albatrosses which were obviously examples of *Thalassarche chlororhynchos* (*bassi!*) in both adult and juvenile phases.

The December notes refer to birds seen by Wilson after the "Terra Nova" had left Auckland on the voyage south. Subsequently Pennell, while returning from Cape Evans to New Zealand, on March 17 and 23, 1911, between Campbell and Macquarie Islands, noted other "Mollymauks smaller than *Thal. melanophrys*" which we can hardly doubt were also examples of *T. chlororhynchos*.

Another example of *Thalassarche chlororhynchos* had been previously reported in the same neighbourhood, while Wilson was in the "Discovery," September 22, 1901, 35° 14′ S., 14° W. (*cf.* Plate XIV, fig. 2), but this would appear to have been in an older phase of plumage. A similarly coloured example had also been noted in the "Discovery" as far east as 33° 38′ E. (*cf.* Plate XIV, fig. 2). This bird, and that shown in fig. 1 of the same plate, had evidently been taken by Wilson for *Thalassarche chrysostoma* (*cf.* Aves, Nat. Ant. Exped. 1907, ii, p. 114), but as we have just inferred we are of the opinion that these represent adult phases in the evolution of plumage changes from young to old in the species *T. chlororhynchos*.

Considerable doubt and confusion has existed in the past as to the status of Verrill's *T. eximius*, and Mathews in his "Birds of Australia" relegated it to the synonomy of *T. chlororhynchos*, and suggested that the latter name should be "retained for the South Atlantic breeding birds" (*cf.* vol. ii, p. 285).

Through the kindness of Lord Rothschild we have been enabled to examine a splendid series of thirty-eight examples of *T. chlororhynchos* from Australian seas and six from Tristan da Cunha. Birds from respective distributional areas can apparently be distinguished as follows, although in the absence of sufficient quite juvenile material we hesitate to express any decided opinion:—

(1) *Tristan da Cunha.*

Adult.—Top of head white: sides of face, nape and hind neck very distinctly washed with grey; chin, throat and underparts white; mantle greyish-brown; ocular streak and loral "smudge" of a darker and more decided tone.

(2) *Australian Seas.*

Adult.—Head, entire neck and underparts pure white; mantle greyish-brown; ocular streak and loral "smudge" faint. When freshly moulted a slight tinge of bluish-grey suffuses the sides of the head, nape and hind neck. This seems to be indicated from an examination of the only August specimen in the series (Broken Bay).

The young of *T. chlororhynchos* is generally described as being similar in coloration to the adult but as possessing a wholly black bill. In our opinion this is not quite correct. In the first juvenile plumage, for example, we believe that the entire head, neck, rump and underparts are pure white; while in the fully adult stage, at any rate in Atlantic-breeding birds, the vertex of the head is pure white, the nape, neck and sides of the face being suffused with bluish-grey. A bird taken alive by Mr. Tom Carter in N.W. Australia answering to the above description of a juvenile was described by Rothschild (Bull. Brit. Orn. Club, 1903, xix, p. 6) as *Thalassogeron carteri.* Subsequently Mathews and others, including Rothschild himself, have regarded *T. carteri* as an immature phase of *T. chlororhynchos.* Through the kindness of Lord Rothschild we have been enabled to examine the type of *T. carteri.* Besides the wholly black bill, the entire head, neck, upper tail coverts, breast, and underparts are pure white. The wings are pure smoky-brown, the back greyer brown. The median underwing coverts are pure white. The bill has undoubtedly the structural characteristics of *T. chlororhynchos,* that is to say, in its proportions it is long and slender, the proximal end of the culminicorn tapers to a somewhat sharp point and does not reach the feathers of the forehead. There is little or no doubt that the black bill in *T. chlororhynchos* is a sign of immaturity, that the bill is probably also black in the downy chick and that the down will be found to be pure white although there are no specimens to prove it in the British Museum collection. The bill is all black in three downy chicks of *T. chrysostoma* (collected on the Shackleton-Rowett Expedition), and Mr. L. Harrison Matthews in his paper on the "Birds of South Georgia" ("Discovery" Reports, vi, vol. i, 1929) has a coloured plate (xlv) of two nestlings of *T. melanophris* in down which both have the bill black.

In *T. chrysostoma* the young in down are not pure white but pale smoky-grey. This smoky-grey down is doubtless correlated with the sooty brownish-grey of the head and nape in what has been regarded as the first juvenile plumage of *T. chrysostoma*. In this juvenile phase the bill is black. If the all-white head, neck, upper tail coverts and underparts of the so-called *T. carteri* is really characteristic of the first juvenile phase of plumage of *T. chlororhynchos,* it is clear that the sequence of plumage phases in this species and *T. chrysostoma* is not identical (see also under *T. chrysostoma*). If this is so the question arises—is it possible to include both species in the same genus? To answer such a question connected with the genetic relationship of the three Mollymauks under consideration—viz. *T. chlororhynchos, T. chrysostoma,* and *T. melanophris*, it is clear that much more material bearing on the actual facts of the serial plumage

phases from chick to adult is required. It should also, we think, be borne in mind that these different phases of coloration in *T. chrysostoma* may have been secondarily determined by the introduction of a melanistic factor, in which case the question of a different generic origin would perhaps not arise. In the meantime we provisionally consider them as belonging to the same genus.

Finally we might add that it seems to us that the plumage phases in *T. chlororhynchos* have been determined by very much the same factors as have influenced those characteristic of *Diomedea epomophora* (=*regia auctorum*), where we find the chick which is covered with pure white down moults directly into a plumage phase which hardly differs from the fully adult stage (see also under that species).

It may further be noted that there is no material in the British Museum collection to prove that either *T. chlororhynchos* or *T. chrysostoma* actually breed in the Notogeal region nor are any breeding colonies known. Thus, although the distribution of the yellow-billed Albatross, *T. chlororhynchos*, is said to extend from the Cape to Van Diemen's Land, there seems to be a complete mystery concerning its life-history or breeding habits in the eastern part of its range.

As far then as the material at our disposal enables us to say, it seems clear that two forms of *T. chlororhynchos* can be distinguished—an Atlantic or Western, and an Australian or Eastern. The name "chlororhynchus" was originally given by Gmelin (1785) to a bird taken in the neighbourhood of the Cape. It must therefore, in our opinion, be used to designate South Atlantic-breeding birds (Gough Island, Tristan da Cunha, etc.) Thus, *T. eximius*, described by Verrill from Gough Island (1895), becomes a pure synonym of *T. chlororhynchos*, while if the Eastern or Australian form is to be distinguished by a sub-specific designation it must be known as *T. chlororhynchos bassi* of Mathews.

35. *Phoebetria palpebrata* (Light-mantled Sooty Albatross). Plates XI, XII, and XIII, figs. 2–6.

Diomedea palpebrata Forster, Mem. Math. Phys. Acad. Sci. Paris, x, p. 571, pl. xv, 1785; *Phoebetria fuliginosa* Salvin, Cat. Birds Brit. Mus. xxv, p. 453, 1896; Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 115, 1907 [part]; *Phoebetria cornicoides* Wilson, *op. cit.* p. 115 [part]; *Phoebetria palpebrata huttoni* Mathews, Birds Austr. ii, p. 297, 1912 (New Zealand Seas); *Phoebetria palpebrata antarctica* Mathews, Birds Austr. ii, p. 303, 1912 (South Georgia).

MATERIAL OBTAINED

No. 40. ♂ 5.xi.1910. 41° 49′ S., 118° 01′ E. Iris dark olive-brown; bill black with violet line on mandible; legs and webs white, tinged with bluish flesh colour.

No. 42. ♀ 21.xi.1910. 44° 30′ S., 155° E. Legs and toes grey or pinkish; webs flesh grey; nails whitish or very pale grey.

T.N. 12. ♀ 27.iii.1912. 52° 11′ S., 107° 25′ E. Iris dark yellowish-olive; bill black with a purplish-blue stripe; legs and feet white, tinged with purple; claws white. Inside of mouth, bill white; fleshy parts violet.

Dr. Wilson's notes on the Light-mantled Sooty Albatross are as follows :—

Sept. 14, 1910.—40° 58′ S., 34° 41′ E., South-east of Cape Colony. One dark-grey type.

Sept. 15, 1910.—43° 21′ S., 41° 06′ E. One individual with lightish grey back and belly ; white eyemark, whitish quills to the rectrices, and a *bluish* streak along the lower mandible ; also leaden flesh-grey feet and webs. This bird was short of the 2nd or 3rd primaries in each wing.

Sept. 18, 1910.—45° 26′ S., 62° 22′ E., South-west of Kerguelen Island. A number, about six or eight, all having light-grey bodies and dark wings, were flying round in the early forenoon and disappeared before noon. The most abundant bird to-day has been *Phoebetria* and nearly all were light-grey bodied, but the light was too bad to be certain of the bill. I think I saw a yellow line on the dark bird and a bluish line on one light-grey bird.

Sept. 19, 1910.—45° 47′ S., 77° 43′ E. One, light variety.

Sept. 21, 1910.—46° 07′ S., 85° 14′ E. Eight or ten flying close round the ship, all having light-grey bodies and so far as one could see the bluish line in the bill, but narrower and less conspicuous than the sooty form with the yellow line on the bill.

Sept. 22, 1910.—46° 32′ S., 92° 58′ E. Two or three very light grey bodies, could not see the bill.

Sept. 23, 1910.—46° 59′ S., 100° 37′ E. One or two with light-grey backs.

Sept. 24, 1910.—46° 49′ S., 108° 27′ E., South-west of Cape Leeuwin, S.W. Australia. One or two with light-grey backs.

Sept. 25, 1910.—46° 30′ S., 116° 07′ E. Eight or ten individuals and every one with a silvery-grey back and body and black head. In no case was there a line on the bill as conspicuous as those with the yellowish line seen in the Atlantic, and the line in one or two was distinctly bluish.

Sept. 28, 1910—44° 33′ S., 138° 56′ E. A light-grey bodied individual but could not see the bill.

Dec. 3, 1910.—52° 12′ S., 172° 48′ E., South of New Zealand. Saw two or three in the forenoon of the white-backed variety. No chance of seeing the colour of the bill-stripe.

Dec. 4, 1910.—54° 34′ S., 173° 50′ E. One or two white-backed individuals.

Dec. 6, 1910.—59° 7′ S., 177° 51′ E. Two or three, with pale grey backs. All with light-grey backs and a blue streak on the mandible : four in the afternoon ; six to eight later, between 6 and 7 p.m.

Dec. 8, 1912.—63° 20′ S., 177° 22′ W. One very white-bodied specimen early in the morning ; three or four grey-bodied birds towards the forenoon.

Commander Pennell has many notes of this bird on the voyage between the Cape and Melbourne, and in nearly every case the light body and dark cap—" giving it the appearance of a Monk's Cowl," as he puts it—were recorded. The absence of the yellow line along the mandible is also noted, but apparently the birds were not close enough to discern the blue line which replaces it in this species.

This species was seen as far south as 72° S., 171° 56′ E., when two " joined company with the ship " on February 12, and on nearly every day either one or two, sometimes several, were recorded in the zoological log until the ship was nearing New Zealand in 54° 23′ S., 160° 39′ E., on March 23.

During the surveying voyage which the "Terra Nova" undertook in the winter of 1911 this Albatross was seen just outside Lyttelton and as far north as 36° 33′ S., 177° E., on July 14.

Leaving Lyttelton again on the second voyage south a light-mantled Sooty Albatross was first met with on December 17, 1911, in 47° 44′ S., 173° 02′ E., and from there daily till the 27th in 64° 56′ S., 175° 30′ W. On March 8, in 73° 32′ S., 174° 12′ E., two were noted:—"One seen at 4 a.m.; this bird's actual body was almost white above and below, the head and wings being dark as usual. It is the lightest *P. cornicoides* I have yet seen. One seen later, had its head, neck, wings, and tail of the normal dark colour. The front of the body above and below white, slightly flecked with dark spots, the body becoming gradually darker as the tail is approached." From that latitude northwards examples were seen every day till March 27 in 52° 16′ S., 167° 31′ E., when several were seen and a female (T.N. No. 12) was captured.

On the third voyage to the Antarctic the species was observed off the New Zealand coast on December 15, 1912, and off and on till December 28 in 67° 50′ S., 166° 24′ W. when a single bird was noted. A month later on January 28, 1913, in 71° 54′ S., 174° 58′ E., this Albatross again appeared in the zoological log, and the entries run daily till the ship reached 54° 22′ S., 164° 49′ E., on February 6.

Then on the voyage home from New Zealand via Cape Horn this Albatross is recorded continuously till April 18 in 42° 09′ S., 55° 15′ W. (N.E. of the Falklands).

As will be seen by the synonomy quoted this Albatross has been divided into a number of different races, but after examining all the examples in the British and Tring Museums—twenty-seven specimens in all—we are not convinced that these races can be upheld. The differences relied on for separating the various sub-species are the colour—which we find varies considerably—and size. In regard to the latter we think that the birds from no given area can be distinguished by measurements.

In regard to *Phoebetria palpebrata auduboni* Murphy, we have seen no example and cannot express any opinion on the validity or otherwise of this race.

36. *Phoebetria fusca* (Sooty Albatross). Plate XIII, fig. 1.

Diomedea fusca Hilsenberg in Froriep's Notizen, iii, (49), p. 74, 1822 (Mozambique Channel); *Phoebetria fuliginosa* Salvin, Cat. Birds Brit. Mus. xxv, p. 453, 1896 [part]; *Phoebetria fuliginosa* Wilson, Nat. Ant. Exped. "Discovery," N. H. ii, Aves, p. 115, 1907 [part]; *Phoebetria cornicoides* Wilson, *op. cit.* p. 115 [part].

When Dr. Wilson wrote the account of the birds collected during the "Discovery" Expedition, he, like other ornithologists at that time, considered the light and dark Sooty Albatrosses to be phases of the same species. It is now generally admitted that they represent two species, viz.: *Phoebetria fusca* with sooty-brown back, only slightly darker on the crown of the head and with a yellow groove along the lower mandible, and *Phoebetria palpebrata* with pale ashy-grey back, the head sooty black, forming a cap, and a blue line along the groove of the lower mandible.

Wilson in the penultimate paragraph of the above-mentioned report wrote as follows :—" I have given for what they are worth the above occurrences of the two extremes of colour together. We did not appear to pass from an area of the one phase to an area of the other in any definite manner, but though there are innumerable intermediate individuals, the white and the black varieties are certainly very noticeable at sea, and it becomes a matter of interest to know what is their distribution in the breeding season."

No examples of this species were obtained during the voyages of the " Terra Nova," and Dr. Wilson still did not realise the distinctions of the two species, continuing to call them light and dark phases—but carefully noting the occurrence of each and whenever possible also recording the colour of the line on the lower mandible.

The following are Dr. Wilson's observations on the voyage to the Cape in the " Terra Nova " and afterwards in the " Corinthic " between that port and Sydney :—

Aug. 7, 1910.—33° 20′ S., 8° 02′ W., *Phoebetria fuliginosa.* The first one appeared to-day. The bill was seen very distinctly and had a yellow streak on the black, not a blue one. The yellow streak is broader than I have seen the blue streak in *Ph. cornicoides* (*palpebrata*). Feet very pale flesh-grey. The whitish quills of the primaries and tail were rather conspicuous, and the white mark on the eye quite distinct.

Aug. 8, 1910.—33° 26′ S., 5° 34′ W., West of Cape Town. Six or seven seen, all very dark and sooty; no light-grey individuals. All had the pale-yellow streak on the bill, not blue, the white half-moon by the eye, whitish quills to the primaries and rectrices, and flesh-grey feet and webs.

Aug. 9, 1910.—34° 30′ S., 2° 33′ W. Five or six, all darker type, and with a yellow line on the bills.

Aug. 10, 1910.—35° 27′ S., 0° 39′ E. Three or four, all dark type with yellow streak on bill.

Aug. 11, 1910.—35° 46′ S., 3° 52′ E. All dark phase with yellow line on the bill, and white eye-mark.

Aug. 12, 1910.—35° 41′ S., 6° 28′ E. Five or six seen.

Aug. 14, 1910.—35° 17′ S., 13° 38′ E., off Cape Town. Four or five, dark phase with yellow line on bill.

Sept. 16, 1910.—47° 54′ S., 54° 57′ E., South of the Crozet Islands. One or two seen.

Sept. 17, 1910.—45° 12′ S., 54° 57′ E. One individual. Yellow streak along the bill distinct and the bird was dark all over.

Sept. 18, 1910.—45° 26′ S., 62° 22′ E., South-west of Kerguelen Island. A number, about six or eight, all having light-grey bodies and dark wings, were flying round in early forenoon and disappeared before noon. The most abundant bird to-day has been *Phoebetria* and nearly all were light-grey bodied, but the light was too bad to be certain of the bill. I think I saw a yellow line on one dark bird and a bluish on one light-grey bird.

Sept. 19, 1910.—45° 37′ S., 70° 06′ E., South of Kerguelen Island. *Phoebetria fuliginosa* and *Macronectes gigantea* are quite absent notwithstanding the number that appeared yesterday. Yesterday was very windy and stormy, with heavy sea and squalls of snow and sleet. To-day there is less sea, bright sunshine, very cold wind, not stormy. More birds to-day than on any previous day.

Sept. 20, 1910.—45° 47′ S., 77° 43′ E. One, dark variety.

Commander Pennell on the "Terra Nova," between the Cape of Good Hope and Sydney, recorded undoubted examples of this species between September 14, 39° 27′ S., 49° 18′ E., and September 19, 38° 53′ S., 70° 25′ E. On the 20th, 38° 46′ S., 74° 19′ E., the entry in the Zoological log is as follows :—"Several seen. Some days a large number, varying from almost black to rather a light brown, some of the lighter ones having black tips to the wings, only one absolute *P. coronoides* (*P. palpebrata*). The bills appear to differ as regard the yellow stripe." On September 23, 39° 15′ S., 83° 33′ E., (S.E. of the Cape of Good Hope), "Great numbers, several distinctly of either sort, but a good many intermediate. Of these latter I could see the yellow on the bill in some, but not in others." And on the 26th and 27th, 40° 48′ S., 94° 20′ E., "Many sooty albatrosses seen. *P. palpebrata* preponderating."

During the voyage home a single bird, "With a uniformly dark head and a yellow stripe on the bill," was seen on April 17, 1913, N.E. of the Falklands in 40° 37′ S., 57° 35′ W.

37. *Sula sula* (Red-footed Booby).

Pelecanus sula Linn. Syst. Nat. edition xii, vol. i, 1766, p. 218 (Ascension Island) ; *Sula piscator* Ogilvie-Grant, Cat. Birds Brit. Mus. xxvi, p. 432, 1898 ; *Sula piscatrix* Sharpe, "Birds of South Trinidad," *Ibis*, 1904, p. 214.

MATERIAL OBTAINED

No. 23. South Trinidad. 28.viii.1910. E. A. Wilson.

According to Mathews specimens of *Sula sula* from Australia are larger in every particular than the birds inhabiting the Atlantic Ocean. This, however, is not borne out by the measurements of the specimens in the National Collection, as will be seen on the following table, though it must be admitted that the series from Australia and the Pacific is very poor.

Specimens from the Galapagos run larger on the average than those from South Trinidad or Little Cayman Islands.

The following are the entries in Dr. Wilson's diary which refer to this bird :—

July 24, 1910.—16° 22′ S., 28° 17′ W., North of S. Trinidad. The South Trinidad Gannet visited us to-day.

July 25, 1910, near South Trinidad. The South Trinidad Gannet came off in some numbers as soon as we sighted South Trinidad.

July 26, 1910, South Trinidad. The Gannet was very abundant and every one that we saw was adult, but we saw neither egg or young, though a few were sitting on their nests.

These Gannets were by no means difficult to capture by hand. They evidently have no enemies at all on the Island for they go to sleep with their heads under their wings, either alone on a dead tree trunk or branch, or in small colonies of half a dozen together on the evergreen bushes high up on the hillside. Here and there one found them sleeping in the hot sun in broad daylight—it is very easy to crawl quietly up to one and seize it by the neck as it awoke.

MEASUREMENTS OF *SULA SULA*.

Brit. Mus. Reg. No.	Sex.	Date.	Locality.	How obtained.	Bill.	Tarsus.	Wing.	Colour of soft parts.
1905.12.30.131	♂	13.ix.1901	South Trinidad	"Discovery" Exped., E. A. Wilson	81·5	26	382	Bill livid blue, red at base; iris dull yellow; legs and feet vermilion red.
1905.12.30.133		13.ix.1901	,, ,,	,, ,, ,,	85	—	395+	Bill bluish livid, red at base; iris dull yellow; legs and feet red
1905.12.30.132	♀	13.ix.1901	,, ,,	,, ,, ,,	81·5	26	382	
1906.12.21.63	♂	4.i.1906	,, ,,	S.Y. "Vahalla," M. J. Nicoll	78·5	27	374	Bill lavender, base pink; round eye pink; gular pruch pinkish, base bluish.
1906.12.21.64	♀	4.i.1906	,, ,,	,, ,,	81·5	26	382	Bill lavender, base pinkish; round eye pink; gular pruch grey; tarsi and toes pale red.
—	—	28.vii.1910	,, ,,	"Terra Nova" Exped. E. A. Wilson.	81·5	27	401	
1896.2.1.3	—	—	,, ,,	Earl Crawford	83	—	401	
1894.5.23.51	♀	i.1890	St. Vincent	G. Stephens	88	25	380	
1892.1.20.260	—	—	Jamaica	W. Osborne	86	26	376	
1844.5.16.19	—	—	,,	*ex* Gould Collection	82	7	362	
1904.8.17.21	♂	13.iii.1904	Little Cayman Is.	S.Y. "Vahalla," M. J. Nicoll	78	24	374+	
1904.8.17.20	♂	13.iii.1904	,, ,,	,, ,,	63	26	368	
1904.8.17.14	♂	13.iii.1904	,, ,,	,, ,,	82	25	372+	
1904.8.17.33	♂	13.iii.1904	,, ,,	,, ,,	84	23·5	377+	
1904.5.28.154	♂	1.ii.1904	,, ,,	S.Y. "Emerald," R. B. Sharpe	—	—	380	
1914.12.1.25	♂	1.ii.1904	,, ,,	,, P. R. Lowe	82	26	373	
1904.8.17.24	♀	13.iii.1904	,, ,,	S.Y. "Vahalla," M. J. Nicoll	82·5	25	368	Iris grey; bill pale blue, base pinkish; round eye pink; gular pruch pinkish grey; feet pale red.
1904.8.17.29	♀	13.iii.1904	,, ,,	,, ,,	87	27	396	
1904.8.17.23	♀	13.iii.1904	,, ,,	,, ,,	83	26	397	
1892.1.20.267	♀	v.1862	Half Moon Kay, British Honduras	Salvin-Godman Collection	86	24	375	
1845.5.5.3	—	—	Honduras	Dyson	87	25	381	
1909.5.2.1	♀	3.ix.1908	Christmas Is.	C. W. Andrews	83·5	25	369	Beak grey blue, feet red.
1909.5.2.2.	♀	4.ix.1908	,,	,,	83·5	25	386	,, ,,
1887.5.1.23	♀	—	,,	Capt. MacLear, R.N.	86	29	382	
1899.1.4.8	♂	—	Diego Garcia	Dr. F. Penrose	81	25	378	
1891.6.18.12	—	—	Mauritius	*ex* Shelley Collection	89	25	390	
1876.3.14.57	♀	1874	Rodrigues	H. H. Slater	80	27·5	385	
1906.12.21.68	♀	13.iii.1906	Assumption	S.Y. "Vahalla," M. J. Nicoll	80	27	355	Bill bluish; face round eye and base lower mandible pinkish red; gular pruch greyish pink; tarsi and webs pale red.
1880.11.18.757	♀	—	Raine Is.	H.M.S. "Challenger"	82	26	387	
1880.11.18.758	♀	April	At Sea, Cape York	,,	83	—	377	
1881.11.7.701	—	—	Queensland	*ex* Godman Collection	78	28	376	
1897.11.17.27	♂	viii.1895	Farquhar Is.	*ex* H. Saunders Collection	87	—	395	
1897.11.30.105	—	1883	.. ..	.. ..	90	29	403	
1856.8.30.44	—	—	Fiji	H.M.S. "Herald"	90	30	396	
1899.9.1.655	♂	4.vii.1897	Clarion Is., Galapagos	Webster-Harris Exped.	90·5	30	403	
1899.9.1.657	♀	4.vii.1897	,, ,,	,, ,,	96·5	29	396	
1899.9.1.658	♂	4.vii.1897	,, ,,	,, ,,	92	28·5	404	
1899.9.1.656	♀	,,	,, ,,	,, ,,	92	29	404	
1899.9.1.654	♂	2.viii.1897	Pacific Ocean	,, ,,	90	28	404	

The colouring of the soft parts of the head and bill are not in life like the coloured drawing I got of them before, which was done some 12 hours after death, and was much too gaudy.

In life the skin of the head and the bill is uniform tinted-body-colour, often almost white. Unfortunately the notebook in which the colour was noted got lost in the coming off.

Lieut.-Commander Pennell, R.N., adds the following observation:—"At 3.45 p.m. half a dozen were roosting on a kind of laurel bush at 1750 ft. on the S.E. side of the main hill. The sun had by this time set on that side of the hill. At 5 p.m. they were roosting on dead tree-trunks, etc., from (say) 800 ft. down."

38. *Sula leucogaster* (Brown Gannet).

Pelecanus leucogaster Bodd. Tabl. Planch. Enlum. p. 57, 1783 (Cayenne); *Sula sula* Ogilvie-Grant, Cat. Birds Brit. Mus. xxvi, p. 436, 1898.

No examples of the Brown Gannet were obtained, but the following notes in Dr. Wilson's diary refer to this species:—

July 8, 1910.—13° 56′ N., 25° 08′ W., S.E. of St. Paul's Rocks. Four or five Brown Gannets came flying round the ship several times during the day, but none settled or came within shot. They were a uniform dull brown all over, except for a variable amount of white on the breast and belly and under the wings. The bill was very pale, whitish-blue at the base, and yellowish-white for the front half. The size of the bird was rather less than that of the common white Gannet of British coasts. Some looked like young adults, others, one at least, looked like an old bird in moult. We were only from 20 to 50 miles from the South-Western Islets of Cape Verde Group, between the hours of 7 a.m. and noon, so these birds almost certainly came from there.

July 18, 1910.—North-West of Ascension. A Gannet came in from the open ocean in the West at sundown, sailing and swooping down from a great height in long sweeps with closed wings. It remained round the ship all night and tried to settle on the yards as we could see by the bright moonlight, but we could not see its colour, and it was gone by daylight. It gave a loud squawk rather like a young rook. This might also have been *S. dactylatra* Less. (= *S. cyanops* Sundev.) described from Ascension Id.

39. *Fregata wilsoni* (Wilson's Frigate-bird). Plate I, fig. 2.

Fregata ariel Sharpe, "Birds of South Trinidad," *Ibis*, p. 214, 1904 [part]; *Fregata ariel wilsoni* Lowe, Nov. Zool. xxxi, p. 311, 1924 (South Trinidad).

MATERIAL OBTAINED

No. 21. ♂ S. Trinidad. 28.vii.1910. E. A. W. Iris brown; bill bluish-white; skin between mandibles bluish; legs and feet very pale flesh-colour.

Systematic Notes.—Wilson took the above bird when the "Terra Nova" touched at the island on her way south. He had collected another skin on the "Discovery" when off the island in September, 1901, and this skin is also preserved in the British Museum.

One of us (Novitates Zool. 1924, vol. xxxi, p. 310) has already called attention to an interesting condition of plumage presented by these two specimens, viz. a brown-headed condition. This apparently represents one of two things, viz. either a young phase of plumage which, by a curious chance, has not previously been met with by collectors throughout the entire range of the *ariel* group, or a phase which is anomalous. We have never seen anything similar either in the British Museum or at Tring, and one of us (*loc. cit.* p. 34), as indicated above, thought fit to emphasise the point by distinguishing the South Trinidad form with a new name. As will be observed he made this island form a sub-species of *Fregata ariel.* He now considers it wiser, until further material arrives to clear up the point, to regard the South Trinidad form provisionally as a distinct species, *Fregata wilsoni.*

The following notes from Dr. Wilson's diary refer to two species of Frigate-birds :—

> *July* 26, 1910.—South Trinidad Island. Anchored close off the shore of South Trinidad. There was an enormous number of birds flying about and around the island to the very summits, and before landing we shot two Frigate-birds—one the greater Frigate-bird with a bright red pouch, the other the lesser Frigate-bird with a greyish-blue pouch. We also shot one or two Petrels, *O. trinitatis*, and a *Gygis crawfordi* or two.
>
> We then landed and went to the top of the island, where there is a pretty thick bush of gnarled trees and an abundance of land-crabs. We shot Petrels, Gannets, and *Gygis crawfordi.* We saw absolutely no sign of any land-bird, nor was there any gull or skua or other bird about except the two Frigate birds, but they were never within gun shot on the shore, though they were occasionally to be shot from the ship.
>
> These Frigate-birds interest themselves in the ship's wind-vane and mast-head. They are powerful flyers and they sail very beautifully over the mast-head, picking at the small piece of flannel or canvas attached to the vane.
>
> We saw nothing of their habitat on the island ; it may perhaps be at the other end of the cliffs. They hunted the other birds as we occasionally saw from the ship.
>
> *July* 28, 1910.—20° 57′ S., 29° 07′ W. Three Frigate-birds followed us out for about ten miles. The greater one shows his pouch when flying.

40. *Fregata minor nicolli* (Nicoll's Frigate-bird). Plate I, fig. 1.

Fregata minor nicolli Mathews, Austral. Av. Rec. ii, p. 118, 1914 (South Trinidad) ; Lowe, Nov. Zool. xxxi, p. 309, 1924.

MATERIAL OBTAINED

♂ South Trinidad Island. 28.vii.1910. E. A. W. Bill horn-yellow and grey ; skin under chin and throat scarlet ; iris brown ; feet and legs bright red.

It says a good deal for the close and discriminating work of Mathews and Rothschild when we note that at the time when Wilson took this bird in South Trinidad

only two species of Frigate-bird were recognised in the Catalogue of Birds in the British Museum (vol. xxvi), and that this very specimen has been described (in MSS.) as an example of *Fregata aquila*. At the present time five well-differentiated species —*F. aquila ; F. minor ; F. magnificens ; F. andrewsi ;* and *F. ariel*—can be easily recognised, to say nothing of sub-species.

There seems to be no doubt that the above-noted specimen taken by Wilson is a young male of the *Fregata minor* group. Its head has a very peculiar streaky or mottled appearance, and this at first sight might easily be ascribed to the dark greenish feathers of maturity " coming in " among the white head feathers of immaturity. A close inspection, however, reveals the fact that these dark feathers are irregularly fringed with white, a condition, or phase, of plumage which we have only once noted before, viz. in a specimen collected by Nicoll from this self-same island. The white of the foreneck has the " iron rust-staining " which is such a peculiar feature of the plumage of certain Frigate-birds. In the case of *Fregata minor* one of us has already called attention (*loc. cit.* p. 300) to the fact that nestling and immature examples from the Indian and Pacific Oceans invariably exhibit a tinge of rusty, in greater or less proportion, on some part of the head, neck, or breast. This statement was true as far as it went, but it did not go far enough ; for in reality the rusty coloration is not only a geographical peculiarity but also a *specific* hall-mark confined to *F. minor*, *F. ariel*, and *F. andrewsi*. It is even absent from *F. magnificens magnificens* of the Galapagos, although those islands are in the Pacific. But *F. m. magnificens* may be presumed to be merely an outlying colony of *F. m. rothschildi*, which latter race occupies the whole basin of the Caribbean Sea and Mexican Gulf, and from which the rusty coloration is also absent. The fact that *F. magnificens* is found in the Pacific at all may be an " accident " dependent on the narrowness of the Isthmus of Panama or its actual absence in the late Tertiary ; so that genetically we may feel fairly certain that the centre of dispersal of *F. magnificens* was the Caribbean basin or American Mediterranean. From the Caribbean basin *F. magnificens* also spreads down into the Atlantic along the eastern shores of South America and across to the Cape Verde Islands. The immature of the species typical of the genus *Fregata*—*Fregata aquila*, confined to Ascension Island—are likewise devoid of any sign of rusty coloration.

The island of South Trinidad in the South Atlantic is, as far as we are aware, the sole exception to the rule that the " rusty tinge " on immature examples of *Fregata* is confined to the Pacific and Indian Oceans. On this island two species of *Fregata* are found. In one, *F. minor*, the rusty tinge is conspicuously present ; in the other, *F. wilsoni*, the examples we have do not show it.

This absence of " rusty " in the West Indian area (Caribbean and Gulf of Mexico) and Atlantic, and its presence in the Indian Ocean and the Pacific seems to us to be very remarkable in an " ocean-going " bird like *Fregata* where physical or physiological barriers seem so difficult to define ; but still more remarkable seems to be the fact that where an apparent climatic barrier in the shape of the cold " roaring forties " has

intervened between the Indian Ocean population of *F. minor* and the Atlantic–South Trinidad population it has not been effective, for the distribution of the "rusty" factor is now, at any rate, discontinuous although it may not necessarily have been so in the past, for when the climate in the south was warmer intervening islands may possibly have formed a connecting chain.

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[*Synonyms are indicated by italics.*]

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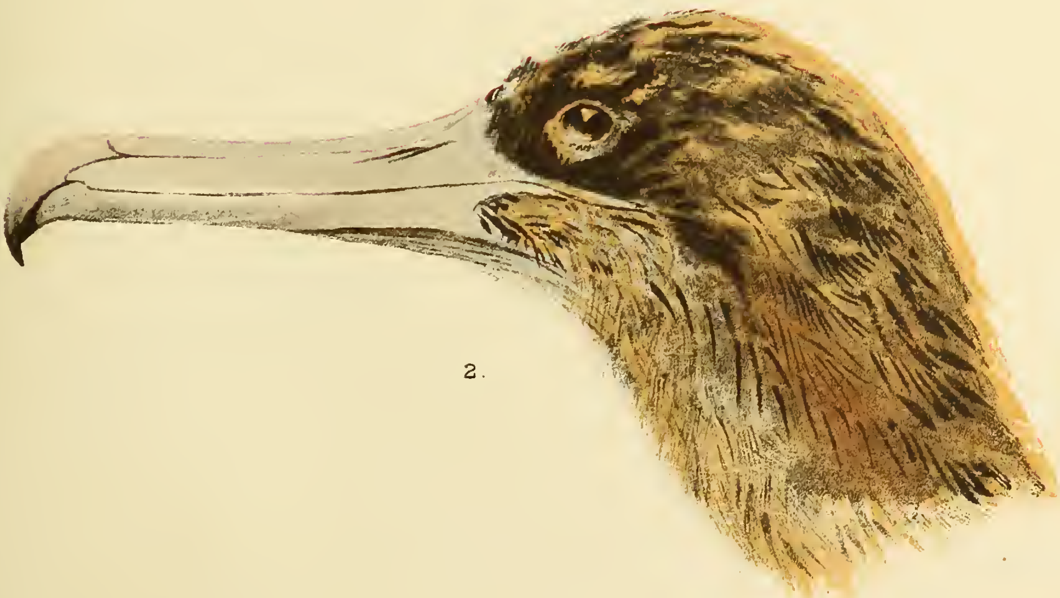

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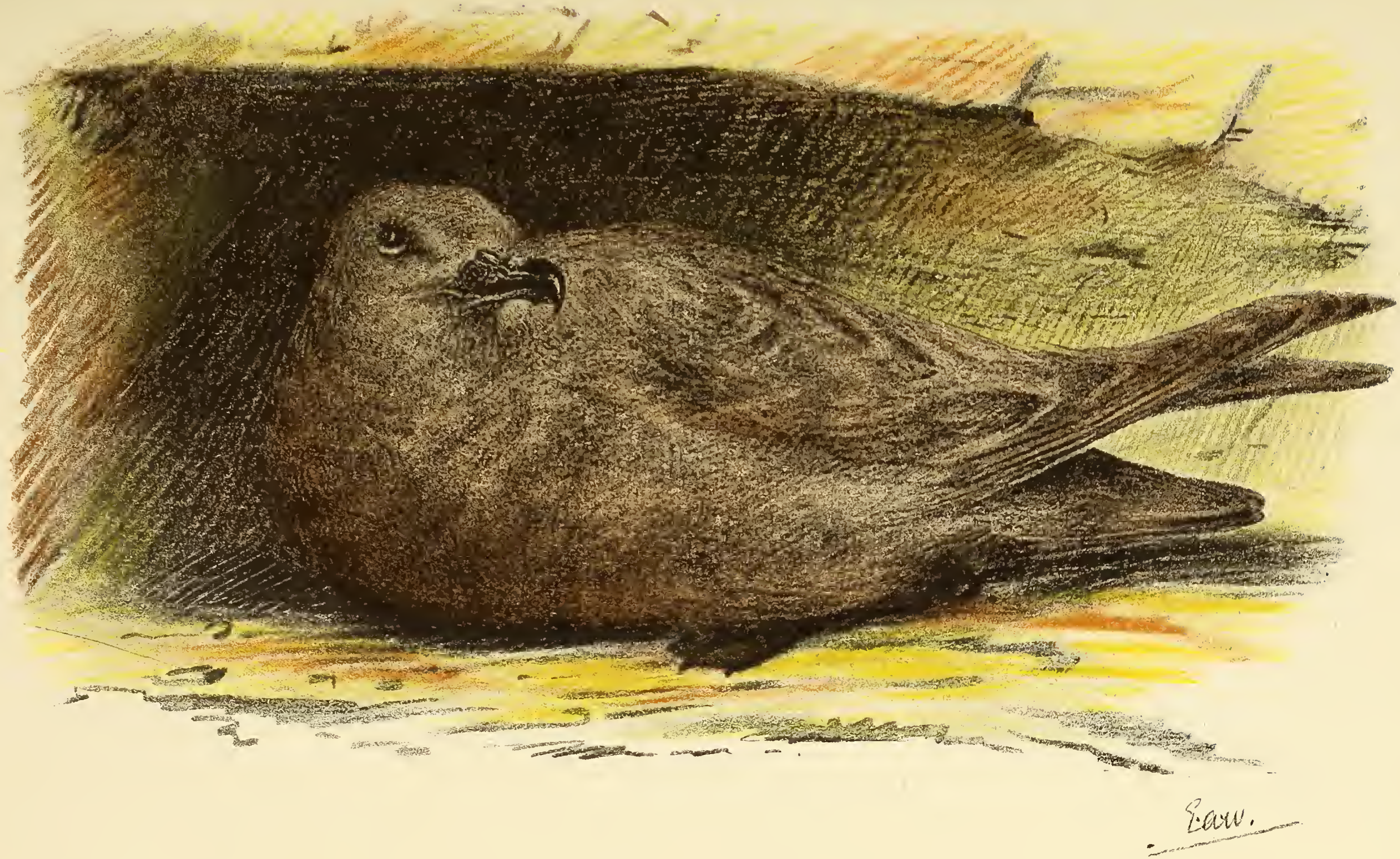

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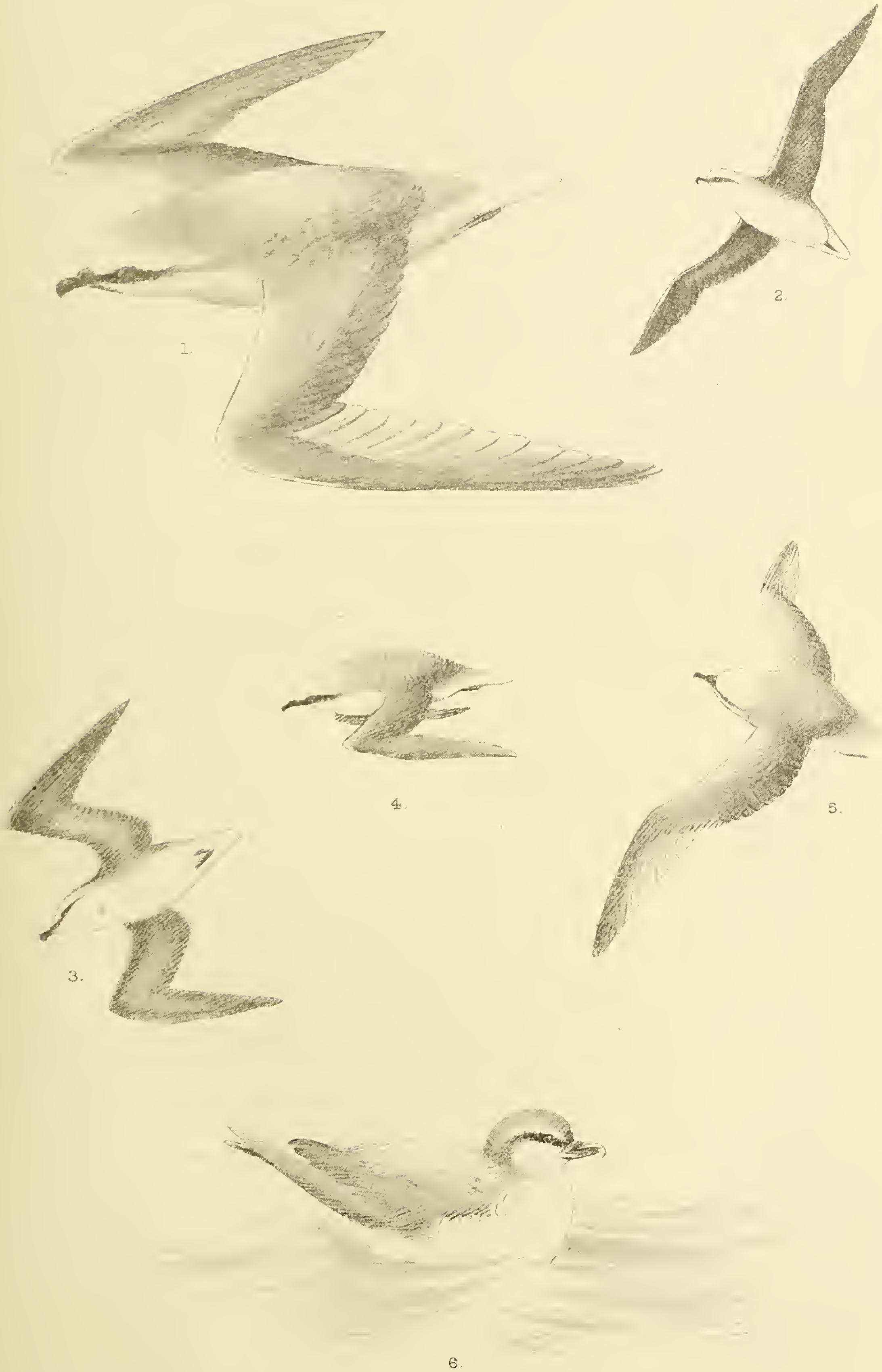

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Zoology, Vol. IV. No. 5.

Birds, Pl. VI.

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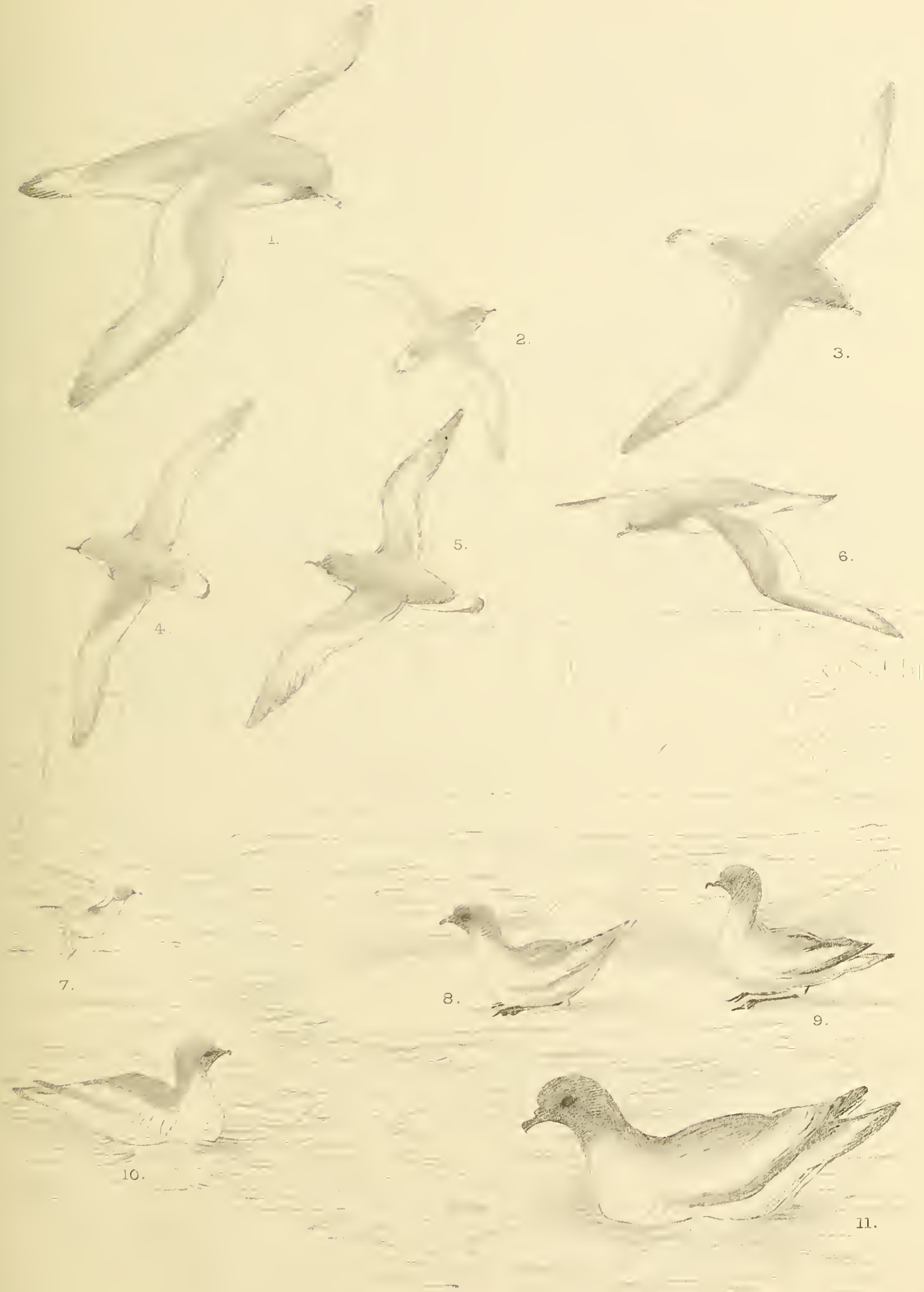

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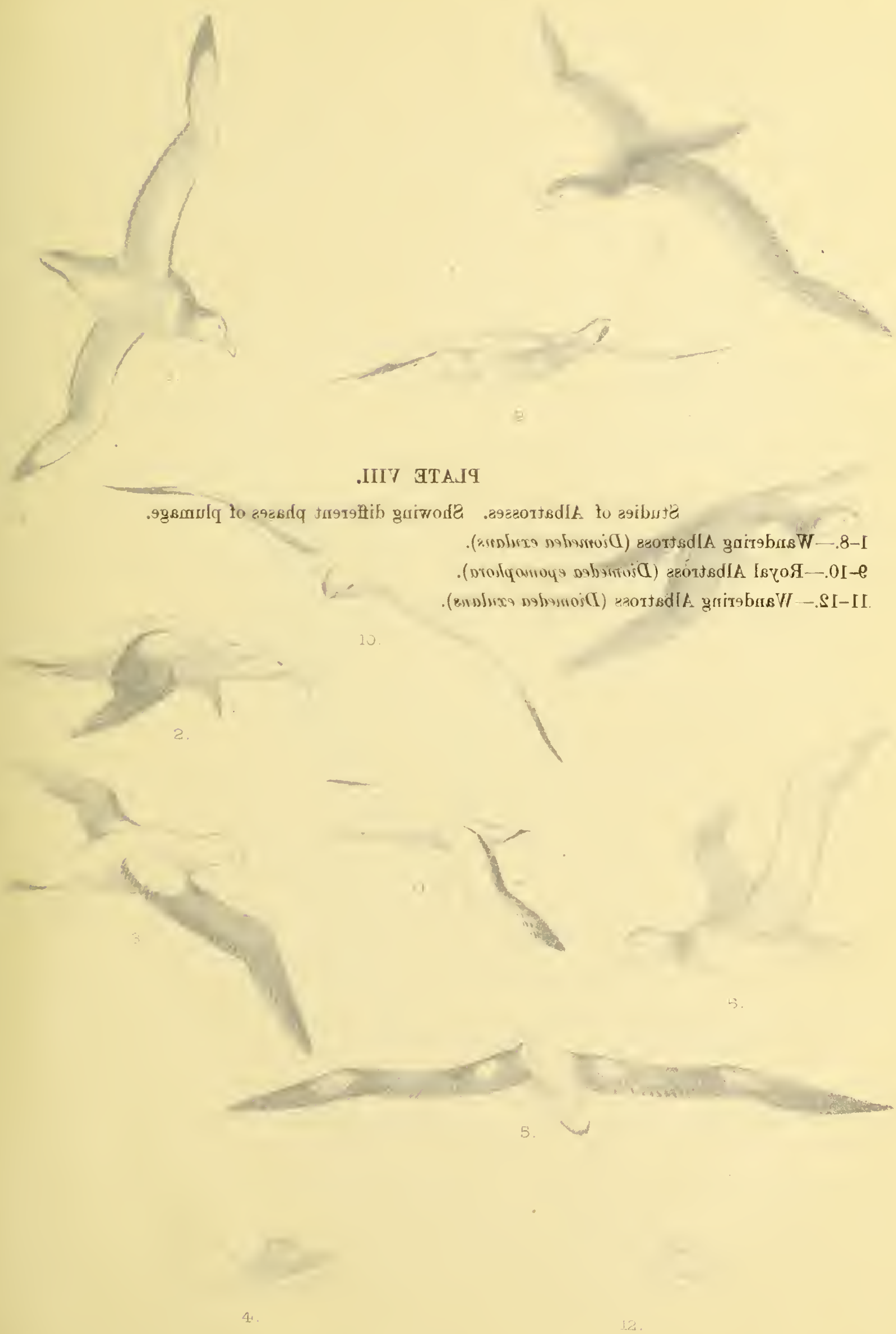
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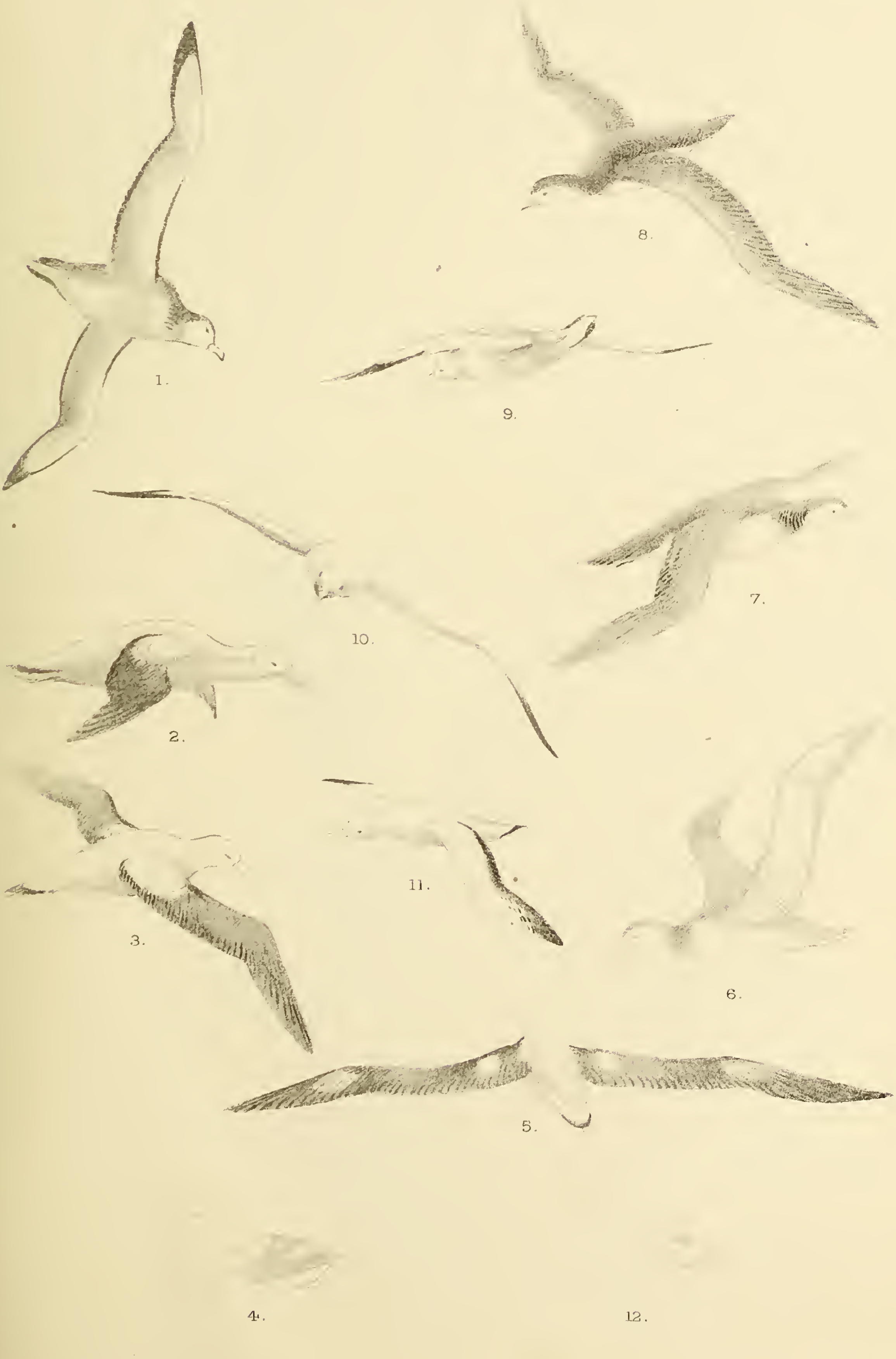
PLATE VIII.

Studies of Albatrosses. Showing different phases of plumage.

1–8.—Wandering Albatross (*Diomedea exulans*).

9–10.—Royal Albatross (*Diomedea epomophora*).

11–12.—Wandering Albatross (*Diomedea exulans*).



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Birds, Pl. IX.

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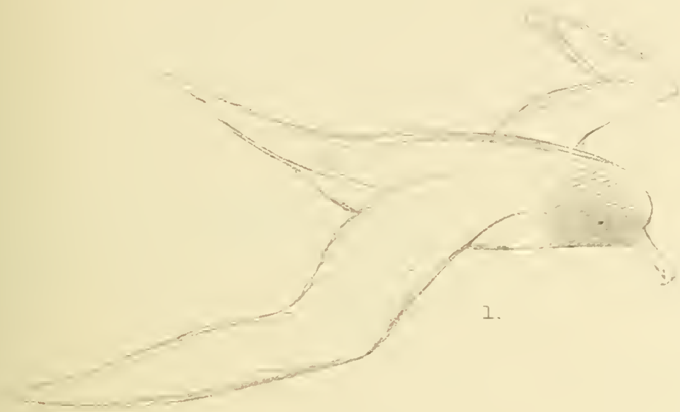

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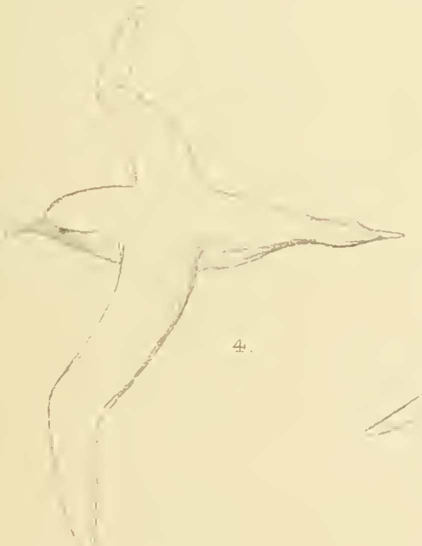

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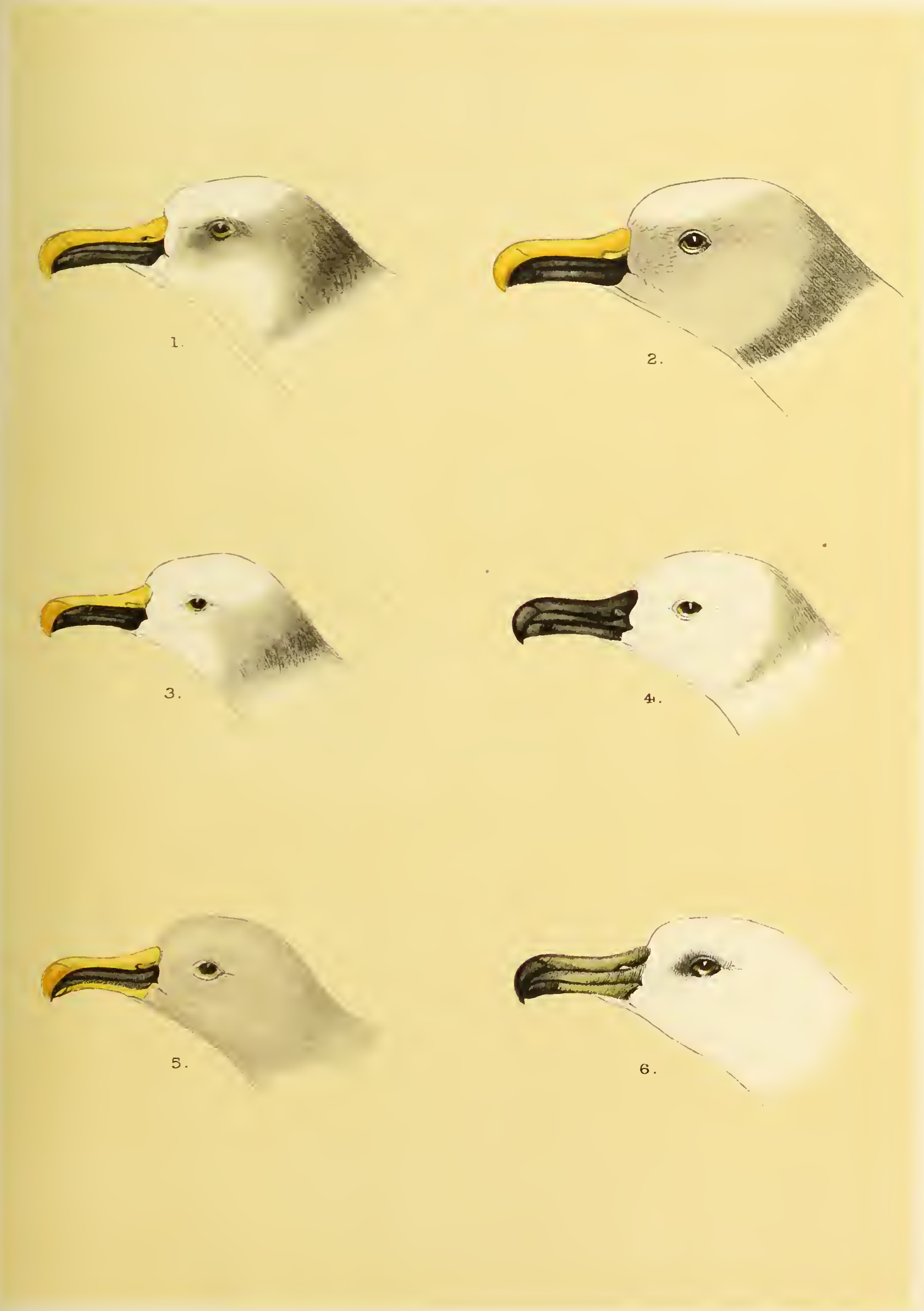

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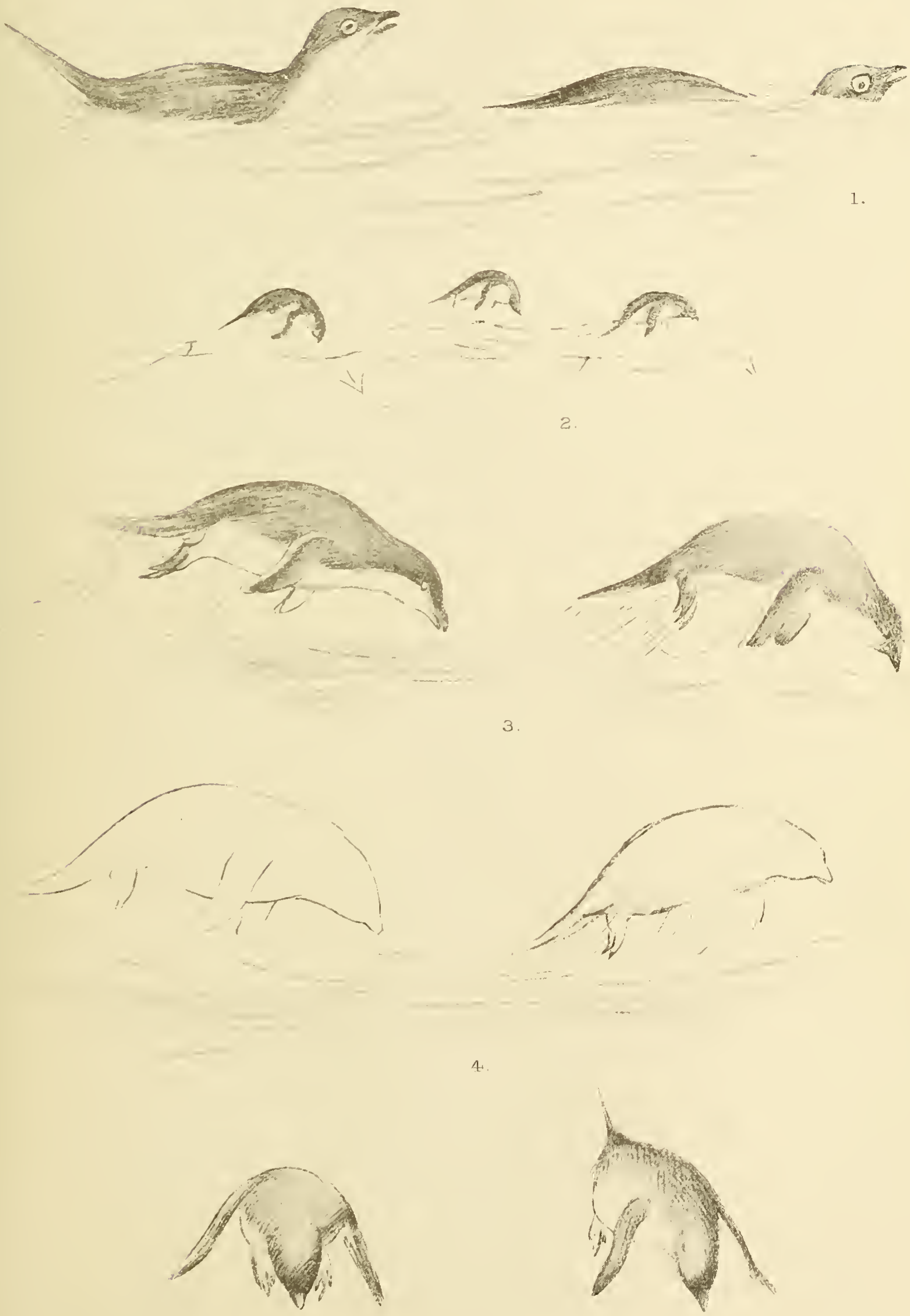

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BRITISH ANTARCTIC ("TERRA NOVA") EXPEDITION, 1910.

NATURAL HISTORY REPORT.

ZOOLOGY. VOL. IV, No. 6. Pp. 195–251.

REPORT ON THE TUNICATA.

PART I.—DOLIOLIDA.

BY

WALTER GARSTANG, M.A., D.Sc.

[illegible]

WITH EIGHT TEXT-FIGURES.

LONDON:

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FIVE SHILLINGS.

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British Museum (Natural History).

This is No. 3 *of* 25 *copies of "Terra Nova" Zoology, Vol. IV., No.* 6, *Report on the Tunicata, Part I., Doliolida, printed on Special paper.*

DOLIOLIDA.

BY PROF. W. GARSTANG.

WITH 8 TEXT-FIGURES.

I. INTRODUCTION AND SUMMARY.

My first words upon submitting this instalment of my report on the "Terra Nova" Tunicata must be an acknowledgment of the great forbearance shown to me by the Trustees and Officers of the British Museum in consequence of my long delay in producing one. When I undertook the task fifteen years ago, the prospect of examining and describing a large and varied collection of Tunicata made a strong appeal to my interests. I had then, I must admit, no idea that the time estimated for this part of the work, even under the distracting conditions of the Great War and its aftermath, would prove but a fraction of that required to master all sorts of nomenclatorial difficulties that lay ahead. I have learned that the only possible way is to proceed by instalments, and to complete one section at a time.

In preparing this report on the small but fascinating group of Doliolids, my work has been much lightened by the precision and care of my immediate predecessors, especially Borgert and Neumann, whose reports on the collections of the "National," "Valdivia," and "Gauss" will long remain classic. No really new species are here added, though I have raised a variety described by Neumann to that rank (*sigmoides*, n. sp.), reduced the status of several others, viz. *resistibile*, Neum., *krohni*, Borgert (*non* Herdman), and *tritonis*, Herd. as varieties of *intermedium*, *mülleri* and *gegenbauri*, and completely revised the classification.

Any novelty my report contains lies rather in the completeness with which I have attempted to record the material, and in the more extensive use of measurement. Every specimen, common or scarce, large or small, has been examined, measured and recorded, and the details summarised for every station separately. I hope, therefore, that the report will serve as a store of data for subsequent use in various directions.

Many, when studying some special problem, must have shared my experience of wanting to know something about the sizes, numbers, and special character of the local forms of some species or other, only to find that on these points the reports of the great expeditions were usually silent. Yet it is only from them, generally speaking, that one can expect light to be thrown on the œcology and bionomics of truly oceanic forms.

My own use of the collections, apart from the mere determination of species, has been directed mainly towards a study of the variation of certain characters in the commoner species, and to an attempt to discriminate between different kinds of "old nurse," which hitherto have proved very refractory.

In both respects distinct progress, I think, has been made, and the results justify the belief that, if biometric methods were more extensively applied to other collections, the results would amply repay the time and labour expended.

The New Zealand waters investigated by the "Terra Nova" have a special interest for the student of the Thaliacea, since it was here, eighty years ago, that Huxley rediscovered the *Doliolum denticulatum* of Quoy and Gaimard, and recognised in it a new type of pelagic Ascidian.

The collections of the "Terra Nova" naturally include few Doliolids from the Antarctic region proper, but the single species represented, the *D. resistibile* of Neumann, was actually taken within the Antarctic Circle, further south than any Doliolid yet recorded.

SUMMARY OF RESULTS.

1. Borgert's sub-genera *Doliolina* (type *mülleri*) and *Dolioletta* (type *gegenbauri*) are raised to generic rank with certain restrictions; a new genus, *Dolioloides*, is proposed for *D. rarum*; and the original genus, *Doliolum*, of Quoy and Gaimard (type *denticulatum*), is restricted in scope. The form and relations of the alimentary canal in gonozooid and phorozooid are taken as diagnostic.

2. The muscular rings, through their connective tissue adhesions, are shown to act as obstacles to the forward extension of the branchial septum and testis during the later stages of growth, thus setting up myomeristic growth-limits, which are prominent features in the diagnosis of most species.

3. These myomeristic limits depend on the period of mesoblastic adhesions between inner and outer membranes, which may be accelerated or retarded by environmental conditions, such as temperature and food-supply. The differential characters of numerous pairs of so-called species are probably therefore no more than environmental modifications, e.g. *tritonis* and *gegenbauri*, *intermedium* and *resistibile*, *mülleri* and Borgert's (but not Herdman's) *krohni*, *denticulatum* and *nationalis*, *valdiviæ* and *mirabilis* (=*chuni*), Herdman's *krohni* and Neumann's *indicum*. When the "species" in these pairs are inseparable by constant characters, they have here been amalgamated under the prior name. This applies already to the first three pairs, and will probably apply ultimately to the others. The unbridged gap between *denticulatum* and *nationalis* is very narrow.

4. *Doliolina krohni* (Herdman) was originally described as possessing an oblique gill-septum (cf. *D. indicum*, Neumann). None of the forms of *krohni* described by Traustedt, Borgert, or Neumann display this character. They are here treated as (*a*) a polystigmatic variety of *D. mülleri* with ventral testis (all three authors), (*b*) a variety of *D. intermedium* with forwardly directed testis (Borgert, Neumann), and (*c*) a new type altogether, with forwardly directed testis, but with ectodermal filaments and a sigmoidal gill-septum (Neumann). For the last a new species, *D. sigmoides*, n. sp., is here proposed.

5. In *Dolioletta mirabilis* (Korotneff), which now includes *D. chuni* Neumann, the 6th muscle-band is shown to be incomplete ventrally both in gonozooid and phorozooid. Fedele's distinction between these two types of zooid as regards the limits of the gill-septum is invalid.

6. Contributions have been made as follows towards the identification of various types of oozooid (larval and old nurses):

(*a*) *Dolioloides rarum.* Gegenbaur's figs. 12, 13 (1856, Taf. XVI) appear to represent

the oldest known oozooid of this species, with muscle-bands twice as wide as the interspaces at 5·5 mm., and with viscera still intact, thus easily admitting of discrimination from others.

(*b*) *Doliolina intermedium*, var. *resistibile* (Neumann) possesses very slender muscle-bands throughout life in the old nurse condition ($<$15 mm.). Its brain lies close before M_5. These points identify it with the first of Gegenbaur's unnamed oozooids (l.c. fig. 14). From his account (p. 300) the larval gut may be inferred to be S-shaped, as in Borgert's gonozooid (1894, Taf. VI, fig. 16), not U-shaped as in *D. mülleri.*

(*c*) Young stages assigned to *Doliolum denticulatum* possess extremely short endostyles (M_2–M_4), and closely resemble two figures of Keferstein and Ehlers (1861, Taf. X, figs. 3, 4). Grobben's metamorphosing specimens attributed to this species (1882, figs. 4, 5) should probably be referred to *D. gegenbauri.*

(*d*) Two types of broad-banded old nurse have been definitely distinguished by measurement of the muscle-bands. In one, attributed to *Doliolina mülleri*, M_4 and M_5 are approximately equal and widest. In another, attributed to *Dolioletta gegenbauri*, M_3 and M_4 are the widest muscles. They remain approximately equal up to a size of 6 mm., above which M_3 predominates. A further distinction is to be found in the otolith, which usually drops away after death in *Doliolina* (both *mülleri* and *intermedium*), but rarely in *D. gegenbauri.*

(*e*) The old nurses of *Doliolum denticulatum* are completely covered by a muscular cuirass (representing M_2–M_8), as figured by Grobben.

7. All specimens of all stages taken have been measured, localised, and reported upon under their separate station-numbers.

II. THE EVOLUTION AND CLASSIFICATION OF DOLIOLIDS.

(*a*) EVOLUTION.

THAT the ancestors of the Thaliacea were sessile primitive Ascidians, with a tailed larva and a metamorphic life-history, and that, of existing Thaliacea, the Doliolids constitute the group most highly adapted to an active pelagic existence is here taken for granted. The evidence in support of these views has already been set out in a series of earlier papers (Garstang, 1928, 1929), so that only a few leading points, which bear on the classification of the group, need here be emphasised. Unlike the Pyrosomata and Salps, the Doliolids have lost the sinistral twist of the intestinal loop, characteristic of their Ascidian ancestors, both in larva, oozooid, and bud, and the musculature retains no sign of its originally plexiform character except in its development, which at an early stage recalls the biradiate plexus, concentrated dorsally, of the *Pyrosomata fixata* (cf. Neumann, Metcalf), which is also recognisable in the "desmomyarian" condition of the Salps (Garstang, 1929). As in *Pyrosoma* the cloaca

has rotated completely to a position directly behind the pharynx, but, unlike *Pyrosoma*, both the oozooid and its buds have become adapted to an actively motile and independent life, by metamerisation of the musculature and restriction of the gill-slits to a posterior position in the pharyngo-atrial septum. All these points are functionally related to one another, and contribute to the efficiency of Doliolids as active planktonic organisms. The Salps also have succeeded in resolving the ancestral floating colonies into chains of semi-independent sexual individuals, but in them the free life of the buds is usually brief, the colonial stage is still dominant, and the task of feeding the young buds falls entirely on the sexless oozooid. Hence the metamerisation of the muscles is less complete in Salps than in Doliolids, and more complete in their oozooids than in their buds. The Doliolids complete the emancipation of their sexual buds (gonozooids) by the highly specialised means of a polymorphic bud-generation, in which the two elder of the three types (trophozooid and phorozooid) remain asexual and successively take over the food-providing function from the parent oozooid, which then specialises entirely as a locomotive vehicle for its progeny (" old nurse " stage).

In harmony with its restricted functions, the oozooid shows few variations of structure, except as regards its equipment for locomotion. The sexual buds, on the other hand, have to swim, feed and reproduce sexually. They show accordingly a much greater diversity.

The chief aim of the Doliolid taxonomer at present is to reconstruct out of fragmentary material the successive phases of an unknown number of complex life-histories, with an approximate knowledge of one, and the debatable sequences of two other life histories as a guide. Direct links between the sexual and asexual generations are rarely to be found, and the assumption of some deep-seated resemblance between the structure of oozooid and blastozooid on which the life-history of *Doliolina mülleri* was traced out by Grobben, is already known to have a very limited application in other cases. The most hopeful line of procedure is to build up an increasingly accurate classification of the bud-generation (especially gonozooids), towards the foundations of which we owe much to Borgert and Neumann, and another of the oozooids, in the expectation of being able to dovetail one into the other as the lines of cross-relationship become apparent.

We can, indeed, already see that in the course of evolution, as might be expected, there have been independent adaptations of oozooid and blastozooid, involving an increasing divergence between these generations as we pass from lower to higher types. Unfortunately the reporters on previous large collections, unable to identify the oozooids before them, have made little attempt to discriminate between their various forms, still less to describe and figure them, except occasionally in the early stages, so that the great collections of the " Challenger," " National," " Siboga " and " Gauss " have been in this particular respect of little use to later workers. Although the collections of the " Terra Nova " are relatively small and local, I have attempted, by

means of detailed measurements, to discriminate between different types of these neglected "old nurses," and to leave a record which may assist further attempts in that direction.

(*b*) CLASSIFICATION.

In his revision of the results of the German Plankton Expedition, Borgert (1894) arranged the ten species which he then recognised (but in three cases with serious doubts as to their validity) under two sub-genera, according to the vertical or strongly arched character of the branchial septum of the gonozooids. This division, though marking a useful advance in method, was never really valid, for, as shown below (p. 214), Borgert misunderstood Herdman's account of the structure of *D. krohni*, in which the septum is neither vertical nor "vorgewölbt." Borgert's arrangement was adopted, however, by Neumann (1906, 1913), and several additional species were incorporated, though the structure both of *indicum* and *resistibile* was at variance with the definition of their sub-genus. Moreover, the names applied by Borgert to the two divisions of the genus, if generally used, would have led to the gradual elimination of *Doliolum* itself, though by every rule of nomenclature this name is inseparable from its type *denticulatum*.

Borgert's division in reality marks a horizontal cleavage of Doliolids into low and advanced types, but a surer basis for such a division, as well as for a phyletic classification, is to be found in the arrangement of the alimentary canal. This, in the species of the *Doliolina* section, lies in the median sagittal plane, as also in *Doliopsis* (=*Anchinia*), while in *Dolioletta*, coupled with a lowering of the œsophageal aperture, the stomach is bent over so as to lie flat upon the ventral body-wall, on its originally right side, and the intestine itself is displaced to the right (cf. figs. 1, 4, 7). This torsion, as I have elsewhere pointed out (1929 *b*) is the exact opposite of that which prevails in the Ascidians and *Pyrosoma*. It follows upon the backward rotation of the cloacal cavity, and preserves the balance of the body for an active career after liberation of the asymmetrical gonads from the intestinal loop.

But at each of the two levels of this morphological change there is a further distinction to be drawn. In the lower division the gut, though without its sinistral twist, still retains the loop-like form of Ascidians, with a descending limb (the œsophagus and stomach), and an ascending limb (the rectum), in every species except *D. rarum* of Grobben, in which the intestine is straightened out axially along the floor of the cloaca, a condition which, with certain differences of detail, is again met with in the oozooids of the higher forms. In the gonozooids and phorozooids of these forms, however (i.e. *Dolioletta* of Borgert), the twist of the intestine to the right takes place in two different ways, viz. as a close spire in the *gegenbauri-tritonis* group, and as a wide horizontal arch in the *denticulatum* group, the anus remaining in the plane of the 6th muscle-band, but median in the 1st group, and definitely parietal in the 2nd.

There are thus four sharply distinguishable arrangements of the gut in the

gonozooids of the various species (text-fig. 1), and these I submit should form the basis of a quadripartite subdivision of the genus, as follows :—

1. *Doliolina* (s. str.).—Alimentary canal forming an upright U- or S-shaped loop in the sagittal plane, e.g. *mülleri, intermedium.*
2. *Dolioloides* (gen. nov.).—Alimentary canal extended horizontally in the sagittal plane, with sub-terminal anus, e.g. *rarum.*
3. *Dolioletta* (s. str.).—Alimentary canal forming a close dextral coil in the middle of the cloacal floor with median anus, e.g. *gegenbauri.*
4. *Doliolum* (s. str.).—Alimentary canal forming a wide dextral arch round the cloacal floor, with anus parietal, on the right side, e.g. *denticulatum.*

These distinctions will be seen in the sequel to be associated with definite combinations of other and more variable characters, the more archaic forms of any character being found in the species of the first two genera, the more advanced forms in the last two, *Doliolum* itself usually furnishing the climax. Thus, to return to the gill-slits, the more primitive forms of branchial septum, which resemble, or deviate least from, its arrangement in the oozooid, are found only in *Doliolina* and *Dolioloides ;* the septum is extended further forwards, both dorsally and ventrally, in *Dolioletta ;* and acquires its maximum extension in *Doliolum.* Similarly in the oozooid, so far as our present knowledge goes, the muscular hoops are narrowest, or most widely separated, in *Doliolina* and *Dolioloides*, broad and closely set in *Dolioletta*, finally fused into a continuous sheet in *Doliolum.* The separation of *Dolioloides* from *Doliolina* is justified not only by the peculiarities of its gut (which are exhibited in both generations), but by the fact that in this type alone the oozooid is known to attain a considerable size (5·5 mm.) without undergoing the atrophy of the alimentary canal which seems to prevail in all the others, while, correlatively, there is still no evidence that it gives rise to asexual locomotive buds, or phorozooids.

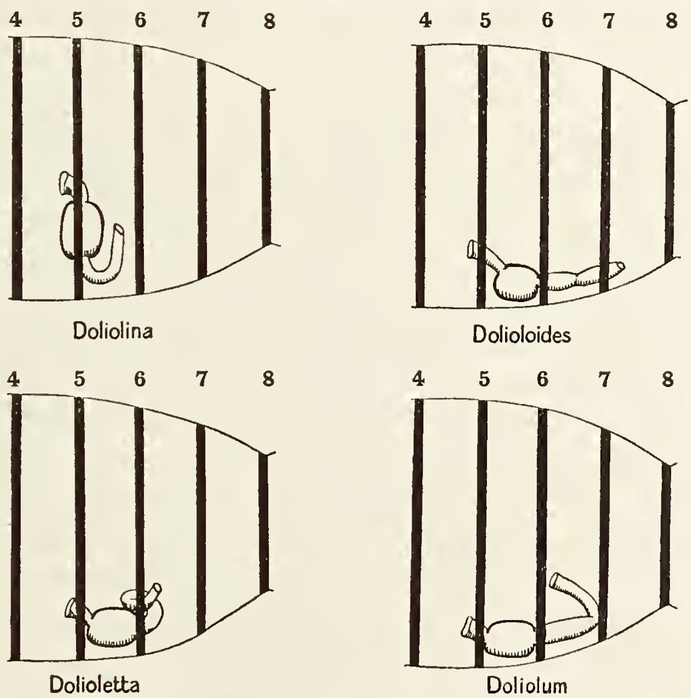

Fig. 1.—Showing the arrangement of the alimentary canal in the proposed genera of Doliolidæ.

Moreover, apart from its greater validity, a primary division of the genus in terms of the alimentary canal has a great practical advantage over schemes based on variations of the gill-septum, since the distinctive characters are readily recognised

even in badly damaged specimens, while the distribution of the gill-slits is difficult to determine when the specimens are contracted or injured by intrusive Copepods. Some examples of the serious confusion which has been wrought by definitions based on the gill-septum will be found below (pp. 214, 225).

Before proceeding to some complicated problems of identification and nomenclature in particular species, it will be convenient to examine certain peculiarities of Doliolid growth which materially affect the question of intra-specific variation.

III. MYOMERISTIC GROWTH-LIMITS.

It is impossible to study either the variations of growth within a Doliolid species or the characters distinctive of related species without realising that the ring-like musculature of the body exercises a kind of metameric control over the general organisation. In old nurses (oozooids), when the alimentary canal has disappeared, the few organs left are seen to be distributed among the various intermuscular spaces—the otocyst in the 3rd, the brain in the 4th, the heart and stolon in the 5th. Closely related species or varieties of sexual zooids may differ in little or nothing more than whether the series of gill-slits begins dorsally, or ends ventrally, at a particular muscle-band or its neighbour, or whether the testis extends forwards to the 4th, 3rd or 2nd. The ovary lies in the 5th or the 6th intermuscular space; the anus in the 5th, 6th or 7th, etc.

In the case of the axial organs of the alimentary canal this relation to the muscle-segments is doubtless largely accidental, and variations are so described merely because the muscle-rings furnish a convenient standard of reference. Thus the endostyle may be described as beginning half-way between two muscle-bands in one species, and exactly at a muscle-ring in another. Nevertheless, over and above this arbitrary use of the muscles as a standard of reference, there is a certain pseudo-metamerism of variation which is no delusion, and is particularly clear in the case of the extent of the gill-slits and of the testis. As the discrimination of species depends largely on these two points, the question demands examination, for the obliquity of the major part of the septum seems to rule out any special utility in the relation, which is merely one of *limits*, and either the formation of new species would appear to be a matter of mutational jumps from one muscle-ring to the next, or the apparent jumps are conditioned by certain checks to extension imposed by the presence of the muscular rings. The latter seems to be the real explanation.

(*a*) *The Branchial Septum.*—What is commonly described as the branchial septum is the two-layered membrane, perforated by the gill-slits, which is slung across the cavity of the body between the pharynx in front and the cloaca behind. It is spoken of as being "attached" to the body-wall along a curving line which terminates dorsally and ventrally at certain points, usually close to one or other of the muscular rings. The word is unfortunate, for in point of fact the "line of attachment" simply marks the parietal boundary between pharyngeal and cloacal spaces, along which their respective epithelia break away from the body wall to become apposed to one another.

In front of the line the pharyngeal epithelium, behind it the cloacal epithelium, are each closely united with the body-wall by fine connective-tissue strands, between which the blood circulates. In this parietal blood-sinus lie the various muscular rings, the contraction of which drives water through the body (cf. p. 240 *). The arrangement might appear at first to be mechanically imperfect, and it certainly differs from that in Salps, in which the muscle-bands are directly fused with the internal membrane, as Keferstein and Ehlers remarked long ago (1861, p. 56). Its effectiveness, however, is attested by the marvellous agility of the living animals, and clearly depends on the firmness of the connective-tissue connexions, especially along the lines of the muscular rings. Sections show that the enclosing membranes of the body-wall adhere to the muscle-bands much more closely and uniformly than they do to one another in the inter-muscular spaces, where the enclosed blood-sinus is capable of considerable changes of volume, pointing to a relative sparsity, greater length, and less rigidity in the fibres which traverse it.

Now the first stages of the branchial septum are accomplished in development by the cloacal invagination sending certain diverticula forwards, dorsally, ventrally, or in both regions, on either side of the median plane (cf. Neumann, 1906, Taf. X, figs. 5, 6). These may be compared to hollow wedges driven in between ectoderm and endoderm at a stage when the muscles are present as rings of undifferentiated mesoderm attached to the ectodermal wall, but still quite independent of the pharyngeal and cloacal epithelia (Neumann, l.c. Taf. X, fig. 10; XI, figs. 16, 20). At this stage the hypobranchial diverticula reach the 4th muscle-band in *denticulatum* (l.c. X, 6), and there is no obstacle as yet to their further extension. But in *gegenbauri* they have only reached the 5th band (fig. 7), and this stage is followed by one of general growth and relatively greater pharyngeal expansion (fig. 8). From the magnification indicated the length of the bud (M_1 to M_8), and the mid-pharyngeal width (along M_4) in the two cases are $0{\cdot}41 \times 0{\cdot}30$ and $0{\cdot}71 \times 0{\cdot}50$ mm., yielding percentage ratios of pharyngeal width to body-length of 66 per cent. and 70 per cent. respectively. The expansion of the pharynx inevitably brings its walls into contact with the muscle-rings, and so initiates the intimate binding of one to the other, on which their functioning depends. The connexion so begun blocks the path for further extensions of the diverticula, and the gill-septum accordingly persists in the position typical of *gegenbauri;* but it is obvious that a slight delay in the process of expansion and adhesion would enable the ventral diverticula to cross M_5 and realise the condition typical of *tritonis* (cf. Borgert's corresponding figure of a gonozooid bud, 1894, Taf. VI, fig. 18).*

Similarly, if the process of expansion took place in *denticulatum* shortly after the

* Remarkably enough a figure of Uljanin's (1884, Taf. XII, fig. 7), representing a median bud, shows this to have actually happened in the offspring of one of the great Mediterranean nurses which Neumann has claimed to be *gegenbauri*—a convincing proof of the specific identity of *gegenbauri* and *tritonis*. Owing to Uljanin naming it *ehrenbergii*, I did not detect its significance until after this chapter had been written (cf. pp. 216, 224).

stage of Neumann's fig. 6, the result would be a specimen of *nationalis*, with a branchial septum "attached" ventrally behind the 4th ring (cf. Borgert's gonozooid bud, Taf. V, fig. 8). Actually, to make a *denticulatum*, the process is retarded, and the gill-septum moves forward towards the next (3rd) ring before the expansion and adhesion take place.

In this way we see that the differences between the members of these two pairs of so-called "species" are merely matters of a little "more or less" in the growth-rate of the diverticula, and in the rate of pharyngeal differentiation.

This difference is associated with one of size, the buds of *nationalis* being smaller than those of *denticulatum*. Neumann's fig. 6 represents a stage actually earlier than Borgert's fig. 8, as shown by the less differentiated condition of the brain, endostyle, peripharyngeal bands and other organs. Yet from the scale of magnification given one can determine that the oro-atrial length even of Neumann's rudimentary bud (0·28 mm.) is as great or greater than that of the highly differentiated *nationalis* bud (0·27 mm.). The fact that the *nationalis* bud is a gonozooid and the other a phorozooid makes no difference to the argument, since the completed structure of these types of zooid is the same, apart from the presence or absence of gonads.

There is thus a possibility—I put it no higher for the moment—that the "specific" differences in the limiting attachments of the gill-septum in such pairs of species as *nationalis* and *denticulatum*, *gegenbauri* and *tritonis*, *intermedium* and *resistibile*, *valdiviæ* and *mirabilis* (=*chuni*), are ultimately matters of differential growth-rates, and doubtless modifiable by nutrition, temperature, and similar environmental factors, as in other cases. Morphologically in the adult there is a segmental discontinuity in most of these limits, but dynamically in the bud the growth-process which underlies them—the penetrative advance of the cloacal diverticula—is continuous until it is checked by mesodermal differentiation. This operates segmentally, beneath the muscle-rings, and thus produces a discontinuity in the end-results, if there are any differences in either of the growth-rates involved.

I venture to think that if the differences in question were not rendered conspicuous by the numerical jump from one muscle-ring to the next, they would be regarded as coming within the range of natural intra-specific variation, dependent, as in other cases, on environmental as well as constitutional influences. It is doubtful if the test of experiment can ever be applied to these delicate oceanic organisms. In the meantime judgment has to be exercised on the question whether they are varietal or specific, and I propose to deal with each case on its merits (see pp. 210–226 below).

(*b*) *The Testis.*—In several species of *Doliolina* the testis preserves very primitive relations reminiscent of conditions in the Enterogonous Ascidians, in which it is lodged in the intestinal loop. Thus in *D. mülleri* it lies alongside the ascending limb of the intestinal loop, but, owing to the evolutional rotation backwards of the rectum, with the cloaca, on its left, instead of its right side. Its growth here is limited to the vertical plane, in which, when it is fully developed, it forms a ventral hernia (Grobben, 1882,

Taf. III, fig. 14). This condition is also exhibited in the *D. krohni* of Borgert (l.c. Taf. VI, fig. 11, 12), which is probably a variety of *D. mülleri*, and certainly not the original *krohni* of Herdman (see below, p. 214). In the *D. krohni* of Neumann (=*sigmoides*, n. sp., also not Herdman's *krohni*, see p. 214), it still lies alongside the gut, and retains the simple pear-shape, but grows forwards instead of downwards, until it meets the posterior wall of the pharynx, which is bulged forwards as if for its reception (Neumann, 1906, Taf. XIV, figs. 6, 7).

In all other Doliolids (with the partial exception of *D. valdiviæ* and *mirabilis-chuni*) it grows outwards as well as forwards on the left side from its median rudiment, and, on meeting the body-wall, extends as a parietal organ, either straight and horizontally, as in *D. rarum, indicum, intermedium, resistibile, nationalis* and *denticulatum*, or obliquely upwards, as in *D. gegenbauri* and *tritonis*. In *D. mirabilis* (=*chuni*) it begins to grow as a parietal organ, but turns backwards on meeting the branchial septum behind M_4, and in the "Terra Nova" specimen, finishes its growth alongside the stomach once more (cf. Neumann, l.c. Taf. XIII, fig. 10; Taf. XIV, fig. 3). In *D. valdiviæ* it never becomes parietal, but, growing directly forwards on the left side of the stomach, as in Neumann's *krohni* (=*sigmoides*, n. sp.), it turns back on meeting the pharynx behind M_5, and makes a half-circuit round the intestinal loop beneath the cloacal floor (Neumann, l.c. XIII, fig. 8; XIV, fig. 2).

The extension of the testis as a parietal organ involves its penetration between the pharyngeal wall and successive muscle-bands, and there is clear evidence that the muscle-bands, or rather their connexions with the pharyngeal epithelium, constitute definite obstacles to its advance, at least in the later stages of development. The contrivance by which these obstacles have been overcome in the case of the higher species (cf. *Dolioletta* and *Doliolum*) is remarkable. In *D. denticulatum* the testis, instead of enlarging as a whole, sends out a fine thread-like process in advance, which may be called the *stolo perforans*, or apical thread. This penetrates the spaces between a muscle-ring and the pharyngeal epithelium and may extend to a varying distance in the next intermuscular space, until it reaches another muscle-ring, where it is temporarily held up. In the meantime the posterior section of the thread enlarges to the dimensions of the hinder part of the testis, and the apical thread ultimately succeeds in crossing the next muscle-ring. So the process seems to continue, step by step, from one muscle-ring to the next, until the 2nd muscle-ring is reached or passed, while some succeed in passing even the 1st. There is, doubtless, considerable variation in the details of the process (cf. examples, st. 107, 109, p. 246).

The "Terra Nova" material included no specimens of phorozooids carrying gonozooid buds sufficiently far advanced to enable me to study the earliest processes *in situ*, but a fair number of small free gonozooids still possessing peduncles was to be found, and many of these had probably been detached prematurely from their phorozooids. In the smallest specimens (1 mm.) the testis consisted simply of a rounded rudiment in front of the ovary in the 6th intermuscular space, or with an anterior

filiform extension up to M_6. In slightly larger specimens, about 2 mm., the testis extended to M_5 or even M_4; but from 3 mm. upwards almost every stage in extent of the testis from behind M_4 up to M_1 was exhibited irrespective of size. At a little below this size (say 2·5 mm.) most of the gonozooids of *denticulatum* seem to become detached from the phorozooids to lead an independent life, but I am unable to give a figure based upon observation of specimens actually borne by their phorozooids. Grobben gives 2·5 mm. as the minimum size of Mediterranean gonozooids, and Neumann has figured a phorozooid carrying a pair of gonozooids nearly ripe for detachment (l.c. Taf. VII, fig. 3), from which their size may be estimated as about 2·1 mm. They show a testis with an apical thread which has crossed M_6 and nearly reached M_5. From the figures given below as to the extent of the testis in gonozooids of different size, it would seem to be possible for some individuals to complete the whole length of the testis before detachment, but such a proceeding must occur rarely (cf. st. 109, p. 52). The testis first completes its growth in the great majority of cases at a size of 3–4 mm., when the individuals are undoubtedly living an independent life.

Length of Zooids (mm.)	1	2	3	4	5	6	Total
Testis reaching or passing M_2	—	57	**322**	222	11	1	613
,, ,, ,, M_3	—	17	**95**	80	6	—	198
,, ,, ,, M_4	—	**22**	18	3	—	—	43
,, ,, ,, M_5	1	**16**	2	3	—	—	22
,, ,, ,, M_6	**1**	—	—	—	—	—	1
Totals .. .. (Average size : 3·22 mm.).	2	112	437	308	17	1	877

TABLE I, showing correlation of testis length and size of body in Pacific *denticulatum*.

These figures record for the first time the amount of variation in *D. denticulatum* in respect of this character, and are of considerable interest. The maximum size of *denticulatum* gonozooids has been given by Neumann (1913, *b*), after working out the "Valdivia," and "Gauss" collections, as 9 mm. Borgert, after the German Plankton Expedition, placed it at 6 mm. for the Atlantic, and earlier naturalists have assigned a maximum of 4·4 mm. (Krohn, as 2‴) or 5 mm. (Uljanin) for Mediterranean specimens. The dominant sizes are clearly, therefore, much the same in the S. Pacific as in the Mediterranean, though the average is a little higher, but the extent of local variations cannot be accurately envisaged without proper biometric data. Neumann remarks on swarms of large specimens (8–9 mm.) encountered by the "Valdivia" in the Benguela stream, a notable fact in view of the relatively low temperature of W. African waters (l.c. 1906, pp. 231–235).

The Atlantic specimens collected by the "Terra Nova" are insufficient to be

representative of this immense area, but the data they yield are summarized in the following table :—

Length of Zooids (mm.)	2	3	4	Total
Testis reaching M_2	—	**5**	3	8
,, ,, M_3	—	**24**	4	28
,, ,, M_4	6	**15**	3	24
,, ,, M_5	1	**3**	—	4
Totals .. .. (Average size : 3·05 mm.).	7	47	10	64

TABLE II, showing correlation of testis length and body-size in Atlantic *denticulatum.*

They are derived from two equatorial Stations 61 and 63 (midway between Fernando Noronha and Sierra Leone) and from Station 70 (Azores). The latter station yielded all the 4 mm. specimens, and seven out of the eight specimens in which the testis reached M_2.

If we may generalise from these various data, it would seem that the species attains its largest size and greatest sexual development in the more temperate oceanic waters, while in equatorial waters (and in the Mediterranean) there is apparently less bodily growth and the testis rarely reaches M_2.

How far the latter phenomenon is due to earlier maturity it is difficult to say, but a comparison of the two tables throws a little light on the problem. In the S. Pacific, half the 2 mm. individuals, and three-quarters of the 3 mm. individuals showed a testis which reached or passed M_2 ; but in the Atlantic none of the 2 mm. and only one-ninth of the 3 mm. individuals attained the same condition. These differences were associated with a slight difference in the average size of the two populations. The facts mentioned show that, apart from actual rate of growth, extension of the testis lags behind that of the body in the Atlantic specimens as compared with the Pacific—which points to the existence of some special retarding influence other than general nutrition. It may be sought in two directions. Although the influence of actual maturation of the testis at these sizes was presumably excluded, the ovary was noticeably active and lobulate, so that precocious maturation of the ovary, under the influence of higher temperature, may possibly have retarded the extension of the testis. In view of the small size of the ovary, this is hardly likely. More probably a rapid rate of differentiation of the pharynx and connective tissues under the same conditions may have imposed additional obstacles to the passage of the testicular stolon. Earlier maturation (as distinct from mere extension) of the testis itself, added to these factors, would then account for eventual arrest of body-growth at a stage when the testis was still short of its potential limits.

A conspicuous example of a particular testis checked in this way was furnished

by a 4 mm. specimen from Station 70 (Azores). The testis had grown straight forward as far as M_4, which it must have found difficult to cross, for it there bent back on itself, and turned abruptly upwards, its apex ultimately pointing towards M_4 again, but at a higher level up the left side.

Although far from settling this complicated question, the considerations advanced tend to show that the form-differences involved fall well within the range of possible environmental variation, and reveal no constitutional peculiarities between the *denticulatum* of different regions. Neumann, indeed (1913, *a.*, p. 223), has emphasised the occurrence of two distinct forms of *denticulatum*, in the smaller of which the testis is club-shaped and extended only to the neighbourhood of the 4th muscle-ring, while in the larger form the testis is cylindrical and extended to M_2 or beyond it. Obviously the " Terra Nova " material lends no support to this idea of a bi-modal type of variation centred round M_4 and M_2. It is true that Mediterranean naturalists have familiarised us with a small type of *denticulatum* (var. *ehrenbergii*), having a testis ending near M_4 (*e.g.* Krohn, Grobben, Uljanin), but Keferstein and Ehlers stated explicitly that the testis " ragt oft bis in den dritten, *ja bis in den ersten* Zwischen-muskelraum hinein " (1861, p. 63), and illustrated the latter condition in one of their drawings of a 4 mm. specimen (Taf. XI, fig. 2). The variation is accordingly continuous, and the only distinction of the Mediterranean " race " is that it usually fails to achieve the full extension of the testis in its smaller individuals—a failure which is also apparently true of the species in the equatorial Atlantic, though possibly to a different extent.

The apparent difference in this respect between *D. intermedium* of the Atlantic and Mediterranean and *D. resistibile* of the Antarctic is probably strictly comparable.

A similar variability in the length of the testis was recorded by Borgert for his new species *nationalis*, but without any specification of limits.

In *Dolioletta gegenbauri* variations in the length of the testis appear to be less frequent than in *denticulatum*. In the few specimens of the " Terra Nova " collection the testis usually mounted obliquely up the left side until it reached M_2, in two or three specimens only reaching M_3, and in one attaining M_1. In the only descriptive account of Mediterranean gonozooids, Uljanin includes as part of their definition " Hoden . . . bis an den zweiten Muskelreifen reichend " (1884, p. 134, Taf. 7, fig. 5).

In the closely related *D. tritonis*, Ritter described the position of the anterior end of the testis in Pacific specimens as " variable," but " usually in fully developed state slightly behind the 2nd muscle-band " (1905, p. 86, fig. 24), and added " anterior end frequently, though not always, with pronounced hook." This hooked extremity, just behind M_2, is represented in Uljanin's figure of *gegenbauri*.

In his original description of *tritonis* (which he at first regarded as a variety of *denticulatum*), Herdman also emphasised the usual termination of the testis " close to the 2nd muscle-band," but added: " No previous investigators, so far as I am aware, either describe or figure the extraordinary variability in form of this anterior end of the testis " (1883, p. 110, Pl. XX, figs. 6–11). In view of my account of the mode of

extension of the testis in *denticulatum,* I wish to draw particular attention to these remarks and figures of Herdman, as they furnish in another species some striking examples of the same type of development, and of the obstacles furnished by the anterior muscle-bands to the extension of the testis in the body-wall (text-fig. 2). His description and figures speak for themselves, and I need only add a few comments. In figs. 6 and 8 we see that the testis must have been temporarily arrested at M_3, but ultimately succeeded in penetrating under it by means of its stolonial thread. In fig. 6 it was finally arrested at M_2, but in fig. 8 succeeded in traversing even this, though not without difficulty, as shown by its zigzag path. In fig. 7 the testis reached M_2, but its "stolo perforans" turned completely round, and after re-traversing M_3, was finally held up by M_4, where it began to expand. In fig. 10 it traversed M_2, was held up by M_1, turned back, so as to form the terminal hook referred to by Ritter, while its "stolo perforans" continued to burrow backwards through M_2. In fig. 11 the apical thread effected an entrance below M_2, but succeeded in emerging only after the most devious wanderings. The whole of these remarkable cases seem to be inexplicable except on the assumption that the connective tissue adhesions between muscle-bands and pharynx were exceedingly close and tenacious by the time the testis had reached the 3rd or 2nd muscle-ring.

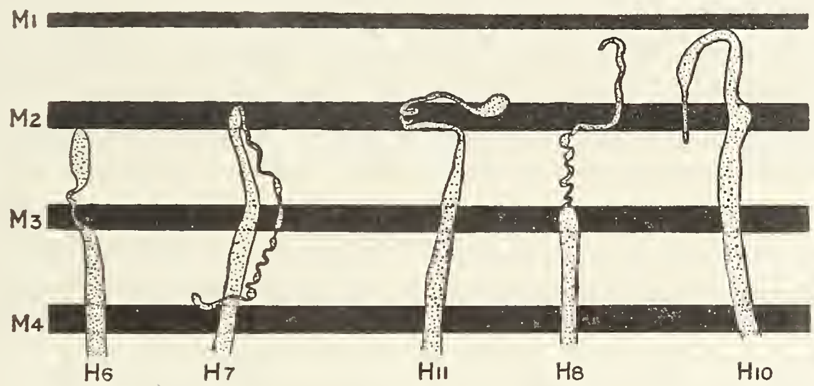

FIG. 2.—Showing, in *Doliolum tritonis,* various irregularities in the anterior termination of the testis (modified after Herdman, 1883).

M_1–M_4, the first 4 muscle-bands. H_6–H_{11}, Herdman's figs. 6–11.

They at any rate support the view here taken that the high frequency of examples in which the testis terminates at a particular muscle-band, as compared with the number of intermuscular terminations, is due not to any particular virtue in this relation, but to the fact that the muscular connexions impose a greater obstacle to extension than does the looser tissue of an intermuscular space.

At first sight the peculiar coilings of the testis in *chuni* and *valdiviæ* look like reactions to similar obstacles at a still earlier period of development, but it is the branchial septum, not a muscle-band, against which the testis is turned back in each case. These species accordingly seem to represent earlier attempts than those of *gegenbauri* and *denticulatum* to accommodate a lengthening testis, *valdiviæ* being presumably more primitive than *chuni* in retaining its testicular coils entirely within the intestinal area. This view accords with the more primitive position of the branchial septum in *valdiviæ* than in *chuni*, but another interpretation is possible (p. 219).

IV. IDENTIFICATION AND NOMENCLATURE.

(*a*) CRITICAL SURVEY.

In general I find myself in close agreement with Neumann (Das Tierreich, 1913), especially in his identification of Gegenbaur's "great nurse" with Uljanin's *gegenbauri*, in opposition to Grobben, Uljanin, and Borgert, who had so strangely associated it with *denticulatum* (=*ehrenbergii*). In some cases, however, Neumann appears to have attached too great a constancy to certain minor differences, and in one case to have made a serious error of identification, so that I propose to take his list of species in the order in which he presents them, and to make my comments under those heads. For convenience of cross-reference I divide it into four sections, corresponding to the four genera which I propose to use, in lieu of the two sub-genera of Borgert, which are added in brackets as used by Neumann.

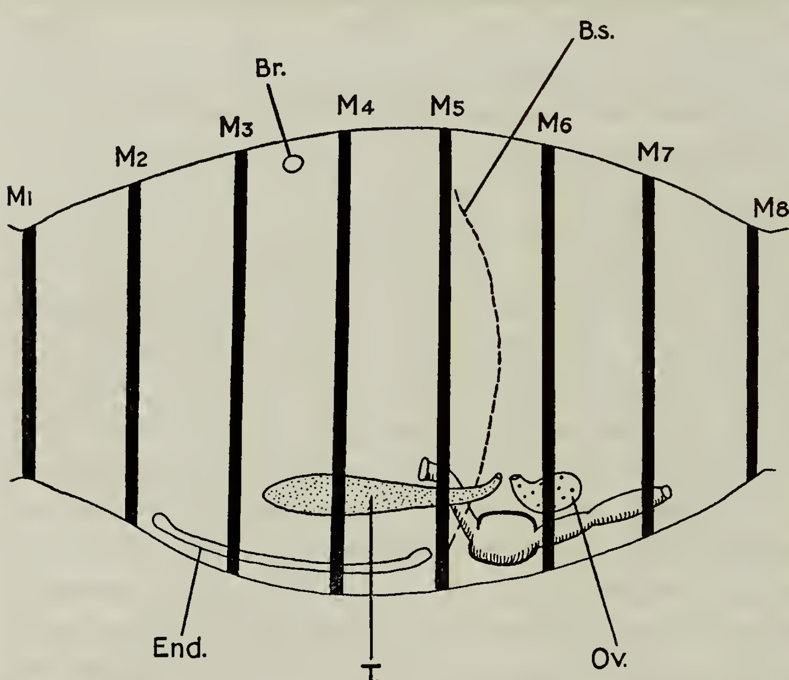

Fig. 3.—*Dolioloides*, gen. nov., showing the systematic characters of *Dolioloides rarum*, Grob. (gonozooid).

Br., Brain; M_1–M_8, muscle-bands; B.s., Branchial septum; Ov., Ovary; End., Endostyle; T, Testis.

DOLIOLOIDES, gen. nov.

1. *D.* [*Doliolina*] *rarum*, Grob. (1882). (Text-fig. 3.)

Neumann omits from his synonyms the third of Gegenbaur's unnamed oozooids (1856, Taf. XVI, figs. 12, 13), which was referred to this species by Uljanin (p. 131) with Neumann's own approval elsewhere (1906, p. 209). There can be little doubt as to the accuracy of this identification, but its acceptance demands some modification of Neumann's definition of the "Amme" owing to the greater breadth of the muscle-bands in Gegenbaur's larger specimen ($2\frac{1}{2}'''$=5·45 mm.) than in Neumann's (4·3 mm.).

In place of "Muskelreifen schmal" read "Muscle-bands narrow in young specimens (<4·5 mm.), broadening later, viz. twice as wide as the interspaces at 5·5 mm. Viscera (always ?) intact."

DOLIOLINA (s. str.).

2. *D.* [*Doliolina*] *indicum.* Neum. (1906). (Text fig. 4.)

The unique resemblance of the gill-septum of this species to that of Herdman's *D. krohni* was overlooked by Neumann, who, with Borgert, misunderstood Herdman's description (see *krohni*, below). It differs from that of Herdman's *krohni* merely in the small number of its gill-slits (5 pairs, as against 25 pairs in *krohni*), but the fact that well-developed phorozooids also possessed the same limited number indicates, as Neumann urged, that this is in all probability a specific character, as in *Dolioloides rarum.* The obliquity of the gill-septum is a primitive feature shared with Doliolid oozooids generally.

3. *D.* [*Doliolina*] *intermedium*, Neum. (1906). (Text-fig. 4.)

To this species may probably be assigned the "einzelne Individuen von *Dol. krohni*," with anteriorly directed testis (text-fig. 4), to which Borgert referred in his

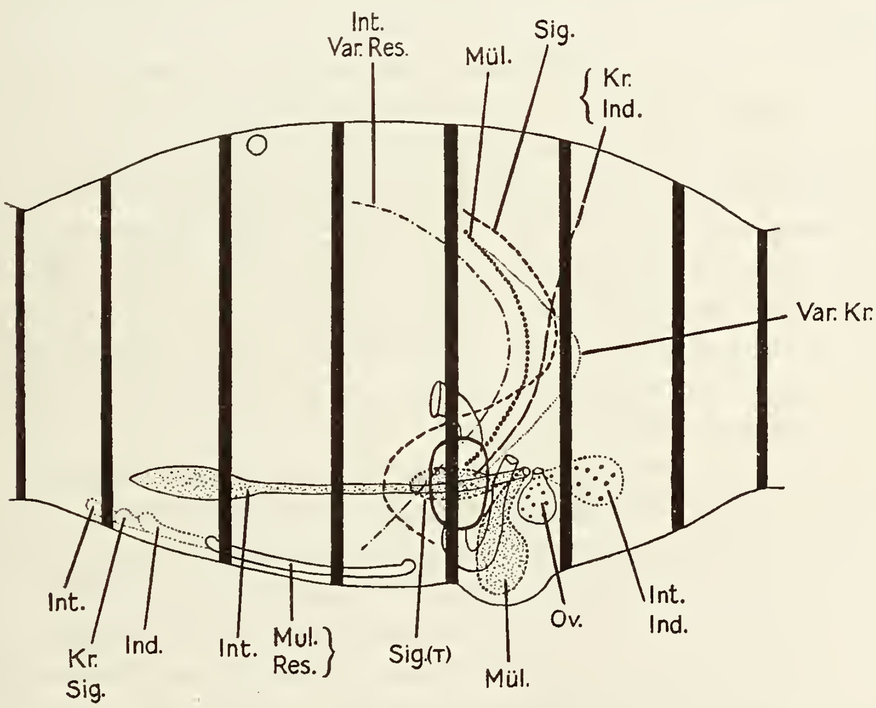

Fig. 4.—*Doliolina*, s. str. Diagram showing the systematic characters of the species *intermedium*, Neum. (and var. *resistibile*, Neum.), *indicum*, *krohni*, Herd. (*non* Traustedt, Borgert, Neumann), *mülleri* (including var. *krohni*, Borgert), *sigmoides*, n. sp. (=*krohni*, Neumann, p.p.).

original account of "*Doliolum sp.*" (1894, p. 18, footnote 2), though it is not clear on what grounds he distinguished originally between them. The position of the ovary in these variants of "*krohni*" is not stated (see *krohni*, below).

Fowler's specimens of *intermedium* (1905, p. 90, as "*Dol.* sp. Borgert") from the Bay of Biscay are of interest as connecting this species with Neumann's *resistibile*

which follows (q.v.). They combined the long endostyle of *intermedium* with the gill relations and slender muscles of *resistibile*.

The oozooid (" Amme ") of *intermedium* is said to be still " unbekannt," but I am strongly inclined to claim for it the first of Gegenbaur's unnamed oozooids (1856, p. 300, Taf. XVI, fig. 14), which is characterised by its exceptionally elongated barrel-shape, its slender muscle-bands and wide interspaces, the muscles being in general less than half the width of the interspaces. The brain is large, situated immediately in front of M_5, and separated by twice its own length from M_4. The dimensions of the body given by Gegenbaur are up to 3‴ in length by 1‴ in width, i.e. 6·5 by 2·2 mm. The otocyst measured 0·04‴ (=0·09 mm.).

Four of Gegenbaur's specimens, stated to be the majority, lacked gill and alimentary canal, but two retained the ventral part of the gill-septum as well as the whole of the alimentary canal. This is stated to have had the same relations as in *troschelii* (i.e., in this case, *mülleri*) with the significant qualification, " Nur . . . dass der Œsophagus mit dem Magen hier ein stärkeres Knie bildet, als es dort beschrieben ward " (p. 301).

Now one of the differences between the gonozooids of *intermedium* on the one hand, and *mülleri* or Borgert's " *krohni* " on the other (as shown in Borgert's Taf. VI, figs. 11 and 16, for " *krohni* " and *intermedium*, and Grobben's Taf. III for typical *mülleri*), is that in the former the stomach and intestinal loop are sharply bent forwards ventrally beneath the œsophagus, so that the whole alimentary canal assumes (from the right side) an S- instead of a U-shape, with a consequential sharpening of the œsophageal angle. Since *Doliolina* is still at an evolutional level in which the alimentary canal of oozooid and gonozooid are alike (cf. *D. rarum* and *mülleri*), the sharp bend of the œsophageal " knee " in Gegenbaur's oozooid may be assumed provisionally to be an *intermedium* characteristic.

From lack of data it is impossible at present to be certain whether this type of curvature is really distinctive of *intermedium* or a mere coincidence in a range of variation. It is approached very nearly in the small oozooid (0·9 mm.) which Borgert attributed, though with considerable reserve, to his " *krohni* " (l.c. p. 25, Taf. VI, fig. 13). This, however, may equally well be another specimen of *intermedium*, provided the length of its endostyle (M. $2\frac{1}{4}$–M. $4\frac{3}{4}$) is not prohibitive (see under *resistibile* below).

Apart, however, from the similarity of the gut in the two cases, there is strong reason for expecting the oozooid of *intermedium* to possess slender muscles, even after the atrophy of the viscera, since this condition has been shown by Neumann to persist throughout life in the closely related *resistibile* of the Antarctic (1913, p. 18, Taf. I, fig. 5), two old nurses of which were also taken by the " Terra Nova " within the Antarctic Circle. In any case it is impossible to accept Grobben's identification of Gegenbaur's oozooid as a " development stage " of *D. mülleri* (1882, p. 63) on account of the large size it attains without any marked broadening of the muscles. Even less possible, for the same reason, as well as from the form of the gut, is Uljanin's identifica-

tion of it (1884, p. 129), with his *ehrenbergii* (=*denticulatum*). *Gegenbauri* and *tritonis* are similarly excluded. Indeed, the form of the gut alone probably excludes all species of *Dolioloides*, *Dolioletta* and *Doliolum;* so that, among N. Atlantic and Mediterranean forms, there remain only Borgert's " *krohni* " and *intermedium* as possible claimants. The close relationship of "*krohni*" to *mülleri* renders it practically certain that "*krohni*" (*pace* Borgert) shares the life-history of the latter. Thus argument by exclusion leads to the same inference as does the positive similarity of the gut, and the analogy of *resistibile*.

Instead, therefore, of " Amme unbekannt " read " Oozooid permanently (?) of elongated barrel-shape, with slender muscle-rings ($<\frac{1}{2}$ width of interspaces). Brain large, immediately in front of M_5, widely separate from M_4. Length up to 6·5 mm."

4. *D.* [*Doliolina*] *resistibile*, Neumann (1913). (Text-fig. 4.)

This and the preceding species furnish another pair of so-called " species " in which the only distinctive feature of the gonozooids is a slight difference in the relations of the gill-septum to the muscle-bands. In *intermedium* the septum is attached so that its gill-slits begin, dorsally and ventrally, " *vor dem fünften* Muskelringe " (Borgert, p. 18), not simply " *bei* dem 5 Muskelreifen " as Neumann puts it (*Das Tierreich*, p. 13), while in *resistibile* the gill-slits begin, dorsally and ventrally, " unmittelbar *hinter dem* 4 Muskelreifen " (Neumann). So that in this pair of " species " the septum arises in one and the same intermuscular space (text-fig. 4). There are no data as to the amount of variation, but Fowler's specimens of *intermedium* (= " *Dol.* sp. Borg.") from the Bay of Biscay (1905, p. 90) were noted as having the gill-plate beginning at the 4th muscle, and muscle-bands of " extreme thinness," so that they seem to have possessed some definitely *resistibile* features.

Intermedium (<6 mm.) has been found chiefly in the N. Atlantic, " besonders in kühlerem Wasser," *resistibile* (<9 mm.) only hitherto in the Antarctic (" Gauss ").

An additional difference in the length of the endostyle is cited by Neumann (M. $1\frac{3}{4}$–M. $4\frac{3}{4}$ in *intermedium*, M. $2\frac{1}{2}$–M. $4\frac{1}{2}$ in *resistibile*), but the inconstancy of this difference is shown by an exceptional case in *intermedium*, cited by Borgert (p. 18, footnote 1), in which the length was also M. $2\frac{1}{2}$–M. $4\frac{1}{2}$. It should be noted that Fowler's specimens of *intermedium* retained the long endostyle, in spite of the *resistibile* features of their gills and muscles.

As there is no obstructive muscle-band to prevent the slight anterior extension of the cloacal diverticula required to convert the smaller into the larger form, I suggest that *resistibile* is simply a large variant of *intermedium*, and should be referred to as *D. intermedium*, var. *resistibile*. Its interest seems to me to be enhanced by putting it thus in relation with its obvious next-of-kin. *D. intermedium* and *resistibile* together hold the records among Doliolids for Arctic and Antarctic distribution, the former having been taken as far north as 60° by the German Plankton Expedition, the latter as far south as 55° by the " Valdivia," 65° by the " Gauss," and 67° by the " Terra Nova."

The definition of the species *intermedium* (s. lat.) should accordingly be amended: "Gill-septum vertical, slightly arched, with numerous gill-slits (12–45 pairs), which dorsally and ventrally begin in the 4th intermuscular space."

5. *D.* [*Doliolina*] *mülleri*, Krohn (1852). (Text-fig. 4.)

Under this species I propose to add "Var. *krohni*, Borgert (non Herdman)" to include the form which Borgert mistakenly referred to Herdman's species (see *krohni*, below), and which differs from the ordinary structure of *mülleri* only in small points that may reasonably be presumed to be of varietal significance, viz. larger size (<6·5 mm.), larger number of gill-slits (<40 pairs), and slightly longer endostyle (M. $2\frac{1}{6}$–M. $4\frac{5}{6}$). This form was taken by the "National" all over the N. Atlantic and seems there to represent the Mediterranean *mülleri* as var. *tritonis* represents *gegenbauri*. Pending adequate knowledge of the variation of these forms, the solution I propose indicates the systematic status of Borgert's form more satisfactorily than would the institution of a new name. Borgert himself spoke of its "auffallende Aehnlichkeit mit *Dol. mülleri*" (l.c. p. 15), and was unable to draw any distinction between the oozooids (on this, however, see under *intermedium* above, p. 212). If he had not misunderstood Herdman's description of the gills of *krohni*, it is very doubtful if he would have separated the form from *mülleri*.

The exceptional forms with longitudinally directed testis, which Borgert also included under *krohni*, have been dealt with under *intermedium*.

6. *D.* [*Doliolina*] *krohni*, Herdman (1888). (Text-fig. 4.)

The forms referred to this species by Borgert and Neumann differ profoundly both from Herdman's type and from one another. Herdman's original description was based on a single group of some thirty specimens taken by the "Challenger" in the S. Pacific off Valparaiso. His brief account runs as follows: "Branchial sac with comparatively few stigmata, which are restricted to the posterior end of the sac. There are about twenty-five pairs which *run in an oblique band posteriorly and dorsally* from a little in front of the 5th muscle band to a little behind the 6th" (1888, p. 49). He also gave a diagrammatic figure of the arrangement (l.c. Pl. III, fig. 1).

It is astonishing that Borgert should have completely misinterpreted this account (1894, p. 15), though the original error was doubtless Traustedt's (1893, p. 4), and still more surprising that Neumann should have failed to detect the correspondence of Herdman's account with the obliquity of the gill-septum in his own new species, *D. indicum* (text-fig. 4), as well as in all Doliolid larvæ.

Neumann, however, has complicated the problem by referring to the same species a form which differs both from this, and all other Doliolids, in the S-shaped attachment of its gill-septum, and in possessing three pairs of lateral epidermal tentacle-like processes. Both characters were constant in all Neumann's specimens, which were taken by the "Valdivia" at two stations in the equatorial Atlantic (Guinea Stream), and at two in the Indian Ocean. Neumann also reports the presence of "*krohni*"—

presumably of his, not Borgert's type—in samples collected by Professor Chun at the Canaries and in the Mediterranean off Solaro. The testis in all his specimens was pear-shaped and directed forwards, thus differing from all Borgert's, except the few individuals mentioned above under *intermedium*.

Neumann speaks of the sigmoidal attachment of the gill-septum as being specially associated with the form and position of the testis; and the two fit one another admirably, as shown in his beautiful drawings (Taf. XIV, figs. 6, 7). But the form of the testis cannot be an epigenetic "cause" of the curvature of the gill, since the sigmoidal curve is also exhibited by the sexless phorozooids.

This remarkable form reminds one among Doliolids of *Traustedtia* among the Salps: in both cases the tentacle-like appendages presumably serve anti-gravitational purposes during periods of passive flotation. I propose to separate it entirely from Herdman's and Borgert's species, and to institute for it a distinct species, *Doliolina sigmoides* (text-fig. 4). Unfortunately, it is uncertain whether Neumann's records of "*krohni*" in the "Gauss" report include any further examples. In the *Bestimmungstabelle* of that report he relegates the characters of his type to a mere footnote (1913, p. 27), and his reference to four gonozooids "der Varietät mit wagerecht liegendem Hoden" does not exclude the *intermedium*-like forms included in the species by Borgert (l.c. p. 21).

Borgert's forms of "*krohni*" have already been dealt with under *intermedium* and *mülleri*.

In his account of the physiology of *D. mülleri*, Fedele (1923, *a.*) has included some figures of this species which are greatly at variance with all other accounts of it, and, if substantiated, might be regarded as establishing a connecting link between the normal type and Herdman's *krohni*. They invariably represent the branchial lamella as sloping obliquely backwards from the back of the endostyle, and three text-figures (figs. 7, 8, 10) show the difference of a whole intermuscular space between its dorsal and ventral extremities. Apart from the mere number of gill-slits, fig. 10 in particular might serve perfectly as an illustration of Herdman's description. Either Fedele, without realising it, had specimens of the true *krohni* (not *mülleri*, as he thought) before him, or his figures of *mülleri* are seriously inaccurate. That error of some kind is involved appears from the inconsistency of Fedele's figures with his own description of the endostyle. Fig. 1 on Tav. 3 represents a young oozooid with a long endostyle of normal extent (2–5); but the three text-figures represent the endostyle in the gonozooids as extending from the 2nd to the 4th muscle-band, slightly overstepping the latter by $\frac{1}{5}$–$\frac{1}{3}$ of the interspace. Grobben's figures show the endostyle of the gonozooid extending from M2$\frac{2}{3}$–M4$\frac{2}{3}$. In Fedele's description, however, the endostyle is stated, in gonozooids, phorozooids, and young oozooids alike (!), to extend "fra secondo e quinto anello muscolare" (p. 141). Until these discrepancies are cleared up, it is impossible to use Fedele's data one way or the other. Fedele's material was studied at Rovigno and Naples.

The species *krohni* thus becomes reduced once more to the type originally described by Herdman, the nearest relative of which is plainly *D. indicum*, as already remarked under that species. Neumann's diagnosis accordingly needs amendment as follows :—

Gonozooid. Barrel-shaped. Gill an oblique lamella, with about 25 pairs of gill-slits, running from a little before M_5 ventrally to a little behind M_6 dorsally. Endostyle long, from M_2 nearly to M_5.

Trophozooid, Phorozooid and Oozooid. Unknown.

DOLIOLETTA (s. str.).

7. *D.* [*Dolioletta*] *gegenbauri*, Uljanin (1884). (Text-fig. 5.)

There is a small point worth noting in corroboration of Neumann's elucidation of the synonymy of this species (1906). Referring to Gegenbaur's classical figure of the buds borne on the blastophore of his "great nurse" (1856, Taf. XIV, fig. 3—as "*D. troschelii*"), Neumann remarks (l.c. p. 217) : "Die Kiemenspalten der Mediansprossen beginnen dorsal beim 3. Muskelreifen, die ventrale Anheftung der Kieme ist nicht sichtbar." Although this is true of four out of the five large median buds represented, Gegenbaur has undoubtedly indicated the ventral gill-slits in the uppermost of the two median buds which are shown on the left side of the blastophore. The gill-slits are only vaguely "shadowed forth," but any one who has examined a number of Doliolids lying in this attitude, ventral side uppermost, knows that the anterior limit of the ventral series is much more conspicuous than the posterior limit, where the series curves towards the dorsal side. The confirmatory feature of this figure is the fact that ventral gill-slits are drawn behind the 5th muscle-ring, *but not in front of it*, where they would nevertheless have been conspicuous if actually present. Had this figure been

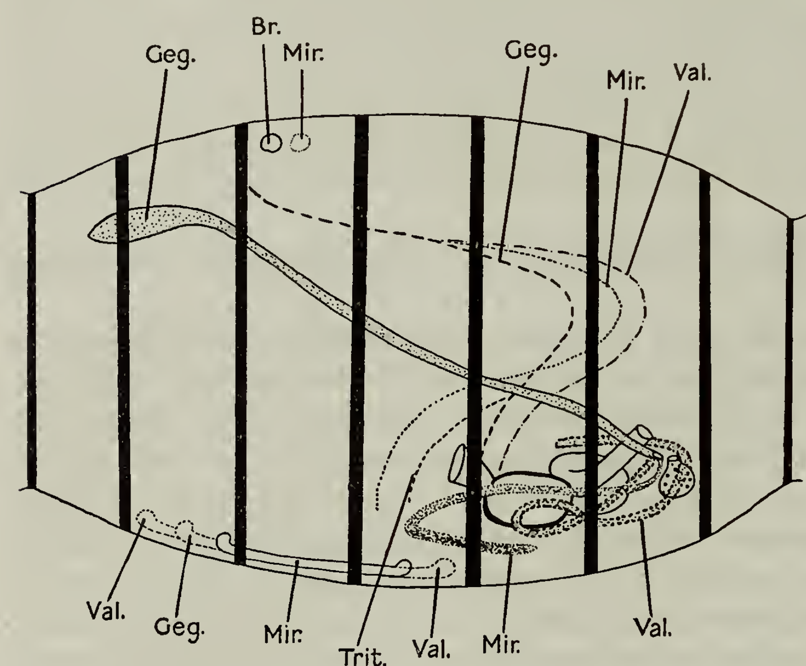

Fig. 5.—*Dolioletta*, s. str. Diagram showing the systematic characters of the species *gegenbauri* (and var. *tritonis*), *mirabilis* (= *chuni*), and *valdiviæ*. The variable features are (1) position of brain, (2) extent of branchial septum, (3) length of endostyle, and (4) position and coiling of testis.

drawn from a specimen of *denticulatum* similarly disposed, the forward extension of the slits along the sides of the endostyle would undoubtedly have been represented.

As a means of distinguishing between the gonozooids of this species and *tritonis*, Neumann has laid great stress on the " long endostyle " of *gegenbauri* (1906, p. 219), which, with that of *valdiviæ*, he has defined as extending " nahezu vom 2 bis fast zum 5 Muskelreifen." This condition he has figured for *valdiviæ* (l.c. Taf. XIV, fig. 2), but there is no figure to substantiate it for *gegenbauri*. Gegenbaur's own illustrations of the median buds not only dealt with imperfectly developed individuals, and in perspective, but in this respect were obviously not drawn with rigorous attention to detail (1856, Taf. XIV, fig. 3). They even represent the endostyle as extending behind M_5 in every case, in two individuals nearly to M_6, while its commencement is drawn at M_2 in one, in the middle of the 2nd interspace in three, and only slightly in front of M_3 in the fifth. On the other hand, Uljanin's original figure of the gonozooid, which is authoritative, shows the endostyle extending from the middle of the 2nd *interspace* to the middle of the 4th (1884, Taf. VII, fig. 5).

My own notes on the " Terra Nova " material indicate a slight variability in this respect, but on the whole confirm the accuracy of Uljanin's figure, so far as observations on preserved material can be brought into comparison.

St. 70 (Azores). GZ. Endostyle from $M2\frac{1}{3}$ or $M2\frac{2}{5}$ to $M4\frac{1}{4}$, $M4\frac{1}{3}$ or $M4\frac{2}{5}$.
St. 83 (S. Pacific). GZ. $M2\frac{1}{6}$–$M4\frac{1}{3}$.
St. 93 (S. Pacific). PZ. $M2\frac{1}{3}$ or $2\frac{1}{4}$–$M4\frac{1}{4}$.

On the evidence adduced, therefore, Neumann's definition in *Das Tierreich* (p. 16), needs modification. Instead of " Endostyl beginnt beim 2. Muskelreifen und erstreckt sich bis über die Mitte des 4. Intermuskularraumes," it should read " Endostyle from before the middle of the 2nd to before the middle of the 4th intermuscular space."

Neumann's concluding remark (l.c.) that *D. gegenbauri* exhibits " *nächst D. tritonis* die grössten, bisher nur im Mittelmeer beobachteten Ammenformen " appears to owe the qualification italicised to a misprint in Ritter's paper concerning *tritonis*, which is corrected below. I believe the series of Gegenbaur's " old nurses " from the Mediterranean still hold the record at 30 mm., with a blastophore measuring 180 mm. as recorded by Uljanin (1884, pp. 73, 88, 132 ; cf. Neumann, 1906, p. 218).

8. *D.* [*Dolioletta*] *tritonis*, Herdman (1888). (Text-fig. 5.)

Neumann follows Ritter (1905) in describing the intestine of the oozooid as " spiralig," and in assigning a length of 125 mm. (!) to the " nurse " itself. This astonishing length is given on p. 88 of Ritter's paper, but on the preceding page the size of the same old nurses is given as 25 mm. with the same " thickness," 7 mm. The statement is therefore a mere misprint.

Ritter, indeed, seems to have corrected the proofs of this paper so badly that it is almost impossible to understand his meaning in certain places, e.g. pp. 92–94, where

references to *gegenbaurii* and *ehrenbergii* are so perplexingly mixed as to obscure completely the significance of his original observations.

There is equal obscurity with regard to his account of the intestine of the oozooids described. He states: "Those oozooids with a tract entirely similar to that of the gonozooid of *D. ehrenbergii* I assume to belong to this latter species" (p. 87); yet on p. 91 he tells us that the gonozooid of *ehrenbergii* is "unknown" (!), and his figure 27, which represents the *ehrenbergii* oozooid, reveals a straight intestine terminating at the 8th muscle! So when we read that the intestinal tract of the *tritonis* oozooid is "similar to that of gonozooid," but "the intestine proper is . . . much shorter and forms less of a spiral, *the length of the loop of the intestine being scarcely greater than that of the œsophagus*" (p. 87), what are we to understand, especially when referred for illustration to accompanying figures of *ehrenbergii* and *mülleri* oozooids—one with a straight gut and the other with a typical U—*both* of which are said to "have the essential features of the present species"! (p. 86)? Had this paper been his only guide, Neumann might well have written "*Amme unbekannt.*"

In point of fact, Fowler in 1905 gave strong reasons for identifying as the young oozooid of *tritonis* a form which in most respects resembles Ritter's figure of the oozooid assigned to *ehrenbergii*, and has no trace at all of an intestinal spire. Certain "Terra Nova" specimens point in the same direction (C_1–C_5).

Borgert entertained considerable doubt as to the existence of valid distinctions between *D. gegenbauri* and *tritonis*, and cited the fact that great numbers of "typisch entwickelter Individuen von *Dol. tritonis*," collected by the "National" in the N. Atlantic, showed no extension of the gill-slits ventrally in front of M_5, "gerade wie bei *Dol. gegenbauri*," while in others the slits extended "bis vollständig in die Mitte des 4. Intermuscularraumes" (1894, p. 20, footnote).

In Herdman's original account of *tritonis* (as *D. denticulatum*, var., 1883, pp. 104–5) the gill-slits ventrally were described alternatively as "commencing behind the 4th muscle-band" (cf. his fig. 11), or as "terminating some place in the 4th intermuscular space." In his figure of a small zooid of only 2 mm. there is no indication of ventral gill-slits in front of M_5 at all (fig. 4).

Borgert and Neumann give no further particulars; but Ihle, reporting on the "Siboga" collections, stated that in East Indian waters, the branchial lamella terminated in some "in der Mitte zwischen dem 4. und 5. Muskelreifen," and in others extended "bis zum 4. Muskelreifen" (1910, p. 14).

To these facts I may add the evidence already cited (p. 203*) that the large nurses found at Villefranche and Capri are known to have produced median buds both of the *gegenbauri* and the *tritonis* type of gill. It may be said that the evidence of true *gegenbauri* parentage for Uljanin's bud, though strong, is merely circumstantial, and I am not in a position to dispute it; but the fact remains that early ideas as to a sharp cleavage between the structure and distribution of a Mediterranean species *gegenbauri* and an Atlantic species *tritonis* have completely broken down. Similarly, with regard

to the endostyle, Neumann's suggestion that it is longer in *gegenbauri* than in *tritonis* lacks any positive basis. The facts concerning its length in *gegenbauri* I have already summarised (p. 217). As regards *tritonis*, Herdman described the endostyle as extending "from *midway* between the 2nd and 3rd muscle-bands anteriorly to *somewhere* in the 4th intermuscular space posteriorly," and his figure shows that this posterior termination may be well behind the middle (fig. 11), i.e. the endostyle may be as long in *tritonis* as in any adult *gegenbauri* yet recorded, and actually longer than in Uljanin's type of that species (1884, Taf. VII, fig. 5).

As no reliable differences have been established between the two "species" at any other stage of the life history, it follows, I think, that the specific separation of these two forms can no longer be justified. The correct course appears to be to treat *tritonis*, Herdman (1888), as a synonym of *gegenbauri*, Uljanin (1884), and to reserve *tritonis* as a varietal name for such gonozooids and phorozooids as show an extension of the ventral gill-slits in front of M_5 (text-fig. 5).

9. *D.* [*Dolioletta*] *valdiviæ*, Neumann (1906). (Text-fig. 5.)

My comments on the significance of the most remarkable feature of this species, the circum-intestinal coiling of the testis (text-fig. 5), have been made above (p. 209). Numerous specimens (<6 mm.) were fished by the "Valdivia" at a single station near the Cape of Good Hope in the Benguela current, and all showed the same peculiarity (Neumann, l.c. pp. 220, 230). As this character is associated with a segmental difference in the extent of the gill-septum ventrally, its distinction from the next species—provisionally at any rate—seems to be warranted.

At the same time, in view of my previous analysis of the growth process, I feel bound to point out that the possibility of this form being ultimately traceable to some "abnormality" of growth-conditions is not excluded by the considerations advanced by Neumann against it (p. 220). The constancy of an abnormal character under very limited conditions of time and place is exactly what might be expected. The whole of the *valdiviæ* stock may have been the produce of a single swarm of nurses reared under peculiar conditions of temperature and food-supply. I agree with Neumann that a direct *gegenbauri* parentage is unlikely; but an origin from *mirabilis* by a precocious differentiation of connective tissues impeding the advance of the gill septum and the parietal outgrowth of the testis, is still conceivable.

10. *D.* [*Dolioletta*] *chuni*, Neumann (1906).

Fedele's discovery at Naples in 1923 of a large adult gonozooid of this interesting type, in company with two phorozooids carrying young buds of *mirabilis* type, has led him to unite these two "species" under the latter name. The same association of a typical gonozooid of *chuni* with a swarm of *mirabilis*-like phorozooids again presented itself in the "Terra Nova" collections, and a comparison of these specimens with Korotneff's and Neumann's accounts has convinced me of the correctness of

Fedele's conclusions. Neumann in *Das Tierreich* (1913), had already indicated the close relationship of the two forms.

11. *D.* [*Dolioletta*] *mirabile*, Korotneff (1891, 1904). (Text-figs. 5–7.)

The linking up of *chuni* with Korotneff's "*Dolchinia mirabilis*" increases the expectation that some interesting surprises are still in store for us in the remaining chapters of their life-history. Described originally from incomplete fragments at Naples as destitute of lateral buds, the species was redescribed thirteen years later from more complete material, and found to possess trophozooids, but of unusual form and distribution, viz. devoid of tentacles, possessing an exceptional number of fine gill-slits, and distributed irregularly among the phorozooids, instead of in lateral rows. This account still awaits confirmation.

Its discovery in New Zealand waters by the "Terra Nova" extends its range from the tropical Atlantic, Mediterranean and Indian Ocean to the S. Pacific.

In his revised summary of characteristics of the *mirabile-chuni* species, Fedele (1923, *b.*) represents the "branchial lamina" of the phorozooid as having a different ventral limit from that in the gonozooid, viz. half-way between M_4 and M_5, instead of at M_4. (There is an obvious misprint on p. 157, line 10 from the bottom, where "al 5° nastro" should clearly read "al 4° nastro.") This distinction is certainly a mistake, for it is at variance not only with my own observations, but with a definite statement of Fedele's own on p. 156, where the limit in his larger phorozooids is stated to be "quasi sotto il 4° anello musculare." In the very numerous phorozooids of the "Terra Nova" collection (5–8 mm. without the peduncle) the gill-slits extend ventrally close up to the 4th ring, exactly as in the gonozooid, and in accordance with Neumann's figure of that form (1906, Taf. XIV, fig. 3). It is clear that in this species, as in *intermedium*, *gegenbauri* and others, the anterior limit of the branchial lamina may slowly shift forwards with growth from the hinder to the front part of an intermuscular space, and that only the muscular rings furnish impassible barriers after functional activity has begun. Such a progressive change does not, of course, exclude variations

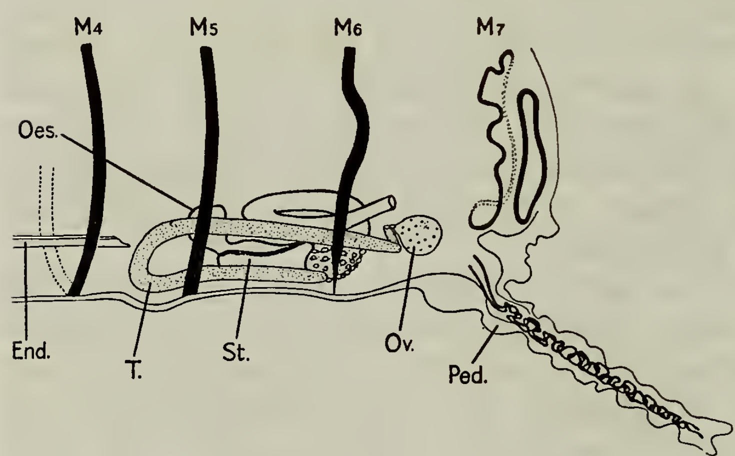

FIG. 6.—*Dolioletta mirabilis.* A young gonozooid (3·6 mm.) with peduncle (2 mm.), showing long recurrent limb of testis and the tapering ventral limb of M_6.

Œs., Œsophagus; St., Stomach; Ped., Peduncle (other abbreviations as in Fig. 3).

of position determined before liberation. Korotneff's original fig. 1, representing a phorozooid just detached, shows another limit between Fedele's two extremes; and Korotneff's fig. 5, drawn by the accomplished artist of the Naples station, shows similar minor variations in young and still sessile gonozooids. In other words, the slight differences mentioned in the connexions of the ventral lamina are not distinctive of the different kinds of bud, but are developmental variations common to both alike.

During my examination of the "Terra Nova" specimens a unique peculiarity of this species came to my notice which may here be recorded. Both in the gonozooid and the phorozooid the 6th muscle-band is incomplete ventrally beneath the intestine (text-figs. 6 and 7). The stomach here is characteristically broad and square, as seen from below, and fills the whole of the space between M_5 and M_6. Together with the duodenal part of the intestine (the so-called "post-stomach"), which is also broader and flatter than usual, this combined region adheres closely to the ventral body-wall, a little to the left of the middle line, over an exceptionally wide area, and it is within this area of adhesion that the muscle-band becomes incomplete. Its right and left limbs approach the middle line immediately behind the stomach, and, on reaching the sides of the post-stomach, taper away on each side to a thin strand of fine fibres which disappear completely.

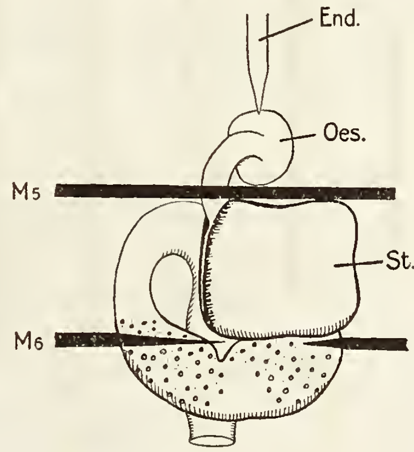

FIG. 7.—*Dolioletta mirabilis.* Ventral view of gonozooid, showing the discontinuous ventral ends of M_6.

The muscle is complete and normal both in *gegenbauri* and *denticulatum.* Its ventral disappearance in *mirabilis* is doubtless due to the exceptionally broad contact between the descending gut and the body-wall, and may be adaptive to the proper functioning of the duodenal region under these conditions. In any case its incompleteness is without precedent.

DOLIOLUM, (s. str.).

12. *D.* [*Dolioletta*] *nationalis,* Borgert (1894). (Text-fig. 8.)

The "auffallende Uebereinstimmung" of this species with *D. denticulatum* was recognised by Borgert in his original account, the only distinguishing character assigned to it being the absence of gill-slits ventrally in front of M_4 (text-fig. 8). This, as I have shown above, may well be a mere varietal character depending on environmental influences, and all the facts, so far as I am aware, are consistent with this interpretation. But the principle of continuity is the only morphological test available for the determination of specific limits, and up to the present there is a minute gap in the evidence required to show connecting links between *nationalis* and *denticulatum.* I

have myself seen no specimen of the *nationalis-denticulatum* type in which the ventral limit of the gill-slits falls exactly at M_4 or in the hinder half of the 3rd interspace, nor can I find any explicit reference to the occurrence of such specimens in the literature of the subject.

Borgert's definition merely states that the gill-slits end ventrally "zwischen dem vierten und fünften Muskelringe," and his figure represents a case in which the limit is very slightly in front of the middle of the 4th interspace (1894, fig. 1). The figure is said to represent an "erwachsenes Geschlechtsthier," but it was certainly not full-grown, as shown by the lobulate, and still functioning, ovary; and its length, calculated from the scale of magnification given, was only 2·9 mm., which is less than the minimum given in the diagnosis, "3 mm. und darüber." In spite of the hundreds of specimens taken by the "National," no information has been given as to the maximum size attained by them. Only from indirect evidence can one ascertain that they were apparently always smaller, and arose from small buds.

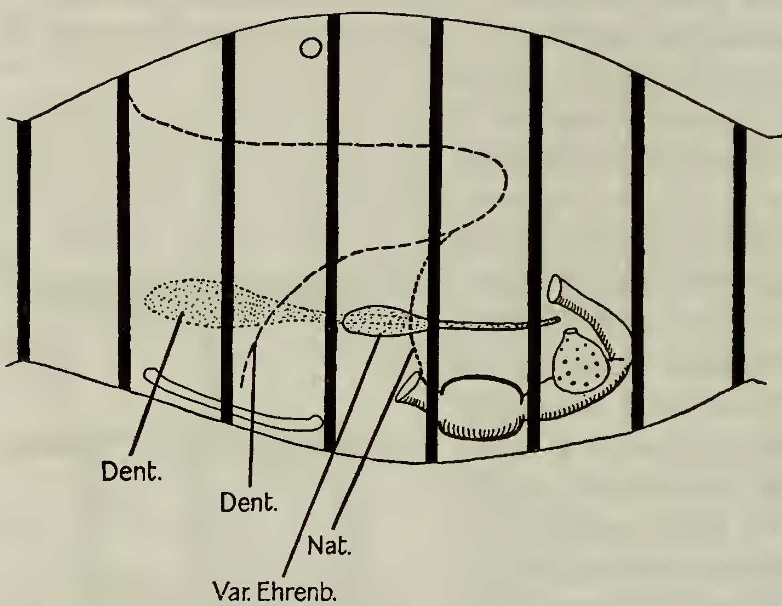

Fig. 8.—*Doliolum*, s. str. Diagram showing the typical differences between *D. denticulatum* and *D. nationalis* in the extent of the branchial septum, and variations in the length of the testis in *D. denticulatum* (including var. *ehrenbergii*), within which that of *nationalis* falls.

On the other hand, Traustedt, who reported first on the "National" collection, and identified this form as a variety of "*D. Challengeri*" (=*denticulatum*, p.p., p. 32), stated that the gill-lamella "bis ein wenig hinter den 4. Körpermuskel reicht" (1893, II, E.a. p. 3), and gave a diagram which represented the lamella as actually reaching M_4 (Taf. I, fig. 14).

Neumann, in the "Valdivia" report, is more explicit with regard to the size of *nationalis*, but adds no new information on the gill and no measurements: "Sind die Individuen durchgehends kleiner als die von *D. denticulatum*, woraus eine geringere Zahl von Kiemenspalten resultiert" (1906, p. 222).

I have not had access to many specimens of *nationalis*, which did not occur in the "Terra Nova" collections, but I have examined various series of Fowler's specimens, which are deposited in the British Museum (labelled H.M.S. Research, 1900), and at University College, London (labelled "Messina," "Plymouth," and "Valentia").

All are phorozooids of small size, from about 0·7 to 2·0 mm., and all show the gill-slits terminating half-way between M_4 and M_5, except one of 1·5 mm. (locality not stated, but apparently "Messina"), in which they only extend to $M4\frac{3}{4}$.

The endostyle in all these specimens begins at M_2, but, as shown below for young *denticulatum*, its length does not keep pace with growth of the body-wall. In all the smallest specimens (0·7–1·5 mm.) it projected distinctly behind M_4 (i.e. End. $2–4\frac{1}{8}$), but very slightly at 1·7–1·8 mm. (cf. St. 111, p. 247).

Accordingly, owing to this gap in the evidence (for Traustedt's diagrammatic figure is hardly sufficient in itself), it seems necessary for the present to preserve the rank of *nationalis* as a distinct species. It is very desirable, however, that this status should be confirmed by a proper biometric study of the relations of *nationalis* to *denticulatum*, especially in some region where both occur together. If the material of the "National" still exists, it might still yield most valuable information.

For, if I may briefly refer to the distributional aspect, a glance at Borgert's quantitative charts reveals some very significant features (l.c. Taf. VII, VIII). *Nationalis* accompanied *denticulatum* almost everywhere in the N. Atlantic, but in a curious allelomorphic fashion as regards density. In the Sargasso Sea *denticulatum* was scarce, *nationalis* absent; *denticulatum*, more steady everywhere than *nationalis*, reached a moderate maximum in the North-Equatorial Stream; *nationalis* reached three great maxima in the hottest waters of the South Equatorial Current and the Florida Gulf Stream, where *denticulatum* was practically absent. Similarly, on the voyage of the "Valdivia" down the west coast of Africa, *nationalis* was plentiful in the equatorial zone, but stopped suddenly and completely when the cool waters of the Benguela Stream were encountered; whereas *denticulatum*, keeping company with *nationalis* through the tropics, blossomed out into great numbers of its largest form in the Benguela Current (Neumann, 1906, p. 231).

These facts, of course, prove nothing as to the varietal or specific rank of *nationalis*, which, by a sound convention, is a purely morphological problem; but, bearing in mind the nature of the differences in structure and size of the two species, the theory that *nationalis* is nothing but *denticulatum* differentiated early and arrested in growth, is at least in complete harmony with the facts of distribution. For the more uniform distribution of the ordinary, cosmopolitan type of *denticulatum* suggests it as the parent form of both extremes, viz. of the quickly bred *nationalis* dwarf of the tropics and the slowly reared giant of the Benguela Current.

D. nationalis visited Plymouth Sound in considerable numbers in 1893, at the end of a wonderfully hot, fine summer, when the Gulf Stream was said to be exceptionally strong. It was the first and only Doliolid I have seen alive, and its movements were fascinating. Unfamiliar then with the systematics of the group, I recorded it as a variety of *D. tritonis*, while noting the different dorsal point of origin of its gill-slits (Jour. M.B.A., III, 1894, p. 222). The specimens, I believe, were all phorozooids. Borgert's report on the Doliolids of the "National," claiming it as a new species, was published

in the following year, and my name for it was subsequently and rightly corrected by Dr. G. H. Fowler (1898), who found the same form in the Faroe Channel.

13. *D.* [*Dolioletta*] *denticulatum*, Q. and G. (1834). (Text-fig. 8.)

This species is of historic interest because the first descriptions of any Doliolid were based upon it, the first in 1851 by Huxley, working on H.M.S. "Rattlesnake" in the S. Pacific, and the second in 1852 by Krohn, who found his specimens at Messina and Naples. Krohn was unacquainted with Huxley's paper, and it is of some importance to realise that these two distinguished investigators independently referred their examples to Quoy and Gaimard's species, and recognised in it a new type of free-swimming Ascidian, related to the Salps. Krohn, however, had several species to describe, including *mülleri*, and, before his paper was published, added a footnote changing the name of his first species from *denticulatum* to *ehrenbergii*, because the "denticulate" character of the oral aperture was common to both. He has been taken to task for changing a name simply because it was "unpassend," but it should be noted that he was not changing an established name, but instituting one that he hoped to establish, and, with the instinct of a good taxonomer, he chose to dissociate his species altogether from Quoy and Gaimard's vague and inadequate account. His own terse description and precise little sketches leave no doubt as to the essential features of the species before him, viz. intestine with wide dextral arch, anus at M_6, gill-lamella 2–6–3, endostyle 2–4, testis on left side, straight, extended to M_4. If some of his critics had been half as careful, this branch of zoology would have been saved from twenty or thirty years of confusion.

The close resemblances and minor differences between Huxley's *denticulatum* and Krohn's *ehrenbergii* naturally led to divergent views as to their relationship, for a racial difference in regard to the normal length of the testis became increasingly apparent (text-fig. 8). Gegenbaur, in 1856, held the two types to be distinct, but Keferstein and Ehlers in 1861 showed that connecting links occurred, and both they and Grobben (1882) united the two types under Quoy and Gaimard's designation. All this time our knowledge of the development and structure of the group as a whole had been making steady progress, which culminated in Uljanin's Naples monograph (1884).

Unfortunately Uljanin was a poor systematist, and on this side of the subject initiated changes which had disastrous effects. Harking back to the idea of a Mediterranean species with short testis, and rediscovering some specimens of a new type with long testis, previously announced by Fol, he revived Krohn's *ehrenbergii* for the short-testicled forms, and jumbled Fol's and Huxley's long-testicled forms together in a new species, *gegenbauri*. The mixed nature of this assemblage was recognised both by Herdman (1888) and Borgert (1894), but the specific limits were not fully cleared up until 1906 by Neumann.

In the meantime Herdman, after reporting on the vast collections of "Challenger"

Ascidians, and doubtless working under strong editorial pressure, dealt with the Doliolids of that expedition in very summary fashion (1888). Neglecting the reproductive organs and alimentary canal, he seriously increased the confusion by modifying old species and creating new ones on the basis of a hasty and superficial scheme of gill-slit distribution, concerning the nature of which he entertained most erroneous notions (cf. his account of separate dorsal and ventral series, the latter uniting with one another above the œsophagus,—1888, p. 42, fig. 6; and, more fully, 1883, pl. XIX, fig. 10; and contrast Krohn's account, 1852, p. 55).

Herdman followed Uljanin in separating Krohn's *ehrenbergii* from *denticulatum*, not because of the difference in testis-length expressly urged by Uljanin, but because of a single word in Uljanin's diagnosis which he failed to detect as a misprint, and which made the gill-lamella terminate ventrally at the 1st, instead of the 3rd muscle-band (Uljanin, l.c. p. 132, 4 lines from bottom—*erste . . . erste*). The unintentional nature of this statement is apparent both from Uljanin's inclusion of Krohn's, Keferstein and Ehlers', and Grobben's species as synonyms, by his references to their figures, and by his explicit approval of Krohn's account of the species (" der die Art sorgfältig beschrieb," p. 133). Herdman strangely picked out this uncorroborated and isolated detail, at variance with the whole history of the species, and partially admitted to be so in one of his own footnotes, as the distinctive feature of " *ehrenbergii*, Krohn " (!), clinched it with a diagram, and, " with a certain amount of doubt," referred a number of " Challenger " specimens to it, but without any figures, except an isolated alimentary canal (pl. III, fig. 7) which fortunately reveals its owner as a common *denticulatum* (cf. Kef. and Ehlers, l.c. Taf. XI, fig. 4).

Lahille (1890), blindly followed Herdman, as Herdman had followed Uljanin's misprint, gave the formula 1–6–1 to the gill-lamella of " *D. ehrenbergii*, Kr." (!!), referred specimens to it from Banyuls, and gave figures of its median buds, gastrozooid and nurse (pp. 64, 65, figs. 47–50).*

After this apparent corroboration, even the cautious Borgert was deceived, and suppressed his first inclination to regard Uljanin's statement as a misprint: " Es scheint also thatsächlich eine Art zu existiren auf welche die von Uljanin gegebene Diagnose passt." Having decided, however, to treat Krohn's *ehrenbergii* as a synonym

* There is a simple explanation of all this in the window-dressing that young students occasionally consider essential to their academic " Thèses," of which Lahille's " Recherches " was a remarkable example. Lahille could not have *seen* the various specimens he figures, because he admits that he only found two individuals of *ehrenbergii* (p. 64). On one of these his fig. 48 *may* have been based, although abnormalities of the kind represented are not common; but well-grown buds, such as those he schematises, could not possibly have been found on so young a nurse. His figures, in fact, are merely diagrams based on drawings in the Naples Monograph (" la belle monographie d'Uljanin "), and more or less adjusted to suit his theory (cf. in order of his figures, Taf. XII, 3, 8; Taf. XI, 3, 7). The secret is betrayed by his fig. 47, which happens to be no *ehrenbergii* at all, but a *mülleri!* His systematic " Tableau," with its embodiment of Uljanin's misprint, was clearly based on Herdman's " Challenger " report, and was probably added as an afterthought, when he had already identified his two specimens of Krohn's, not Herdman's, species from Uljanin's monograph.

of *denticulatum*, he recommended, to avoid confusion, that the new species should be styled "*D. ehrenbergii*, Uljanin" (l.c. pp. 23, 24); which, if one thinks about it, was really a proposal to forge Uljanin's signature.

Ten years later his recommendation took effect, and Ritter referred sundry oozooids from San Diego (but no gonozooids or phorozooids, which alone could display the peculiar character!) to the non-existent, but duly authenticated species "*Dol. ehrenbergii*, Uljanin (not Krohn)"! (1905, p. 91; cf. Fowler, 1905, p. 92).

SPECIES DUBIÆ DOLIOLIDARUM.

1. *D. affine*, Herdman (1888).

The only character given by Herdman which differentiates this form from his *ehrenbergi* is the extension of the gill-slits ventrally "nearly to the third muscle band" (l.c. p. 47, pl. III, figs. 6, 8). As *ehrenbergi* in Herdman's sense has no real existence, and the character given by him to *affine* is a character of the true *ehrenbergii*, Krohn, the species *affine* can be expunged from the list of doubtful species. It disappears as a mere synonym of *denticulatum*, Q. and G. (=*ehrenbergii*, Krohn).

2. *D. ehrenbergii*, Uljanin (1884).

The history of this "species" has been discussed under *denticulatum*. Uljanin's *ehrenbergii* is quite definitely Krohn's species (=*denticulatum*, Q. and G.). "*Ehrenbergii*, Uljanin, non Krohn" is not a doubtful species, but a myth, and disappears.

D. challengeri, Herdman (1888), which was treated by Borgert (1894), as a doubtful species, is regarded by Neumann (1913, b) as a synonym of *denticulatum*. In general I agree, but the species is clearly a mixture, and should be retained in the list of doubtful species until light has been thrown on the exceptional specimens referred to by Herdman (p. 48), in which the gill-slits began dorsally at M_3 "as in *D. tritonis*." They were taken in large numbers at station 242 in June 1875 between Japan and the Sandwich Isles (p. 109). A species of *Dolioletta* (s. str.) is indicated; another form of the *mirabilis* type, with a still more extensive gill-series, is possible. For such a type *challengeri* might have to be revived.

(*b*) THE ENDORSEMENT OF SPECIFIC NAMES.

From the history of *Dol. denticulatum*, *ehrenbergii* and *krohni* recorded above, it must be apparent that there is something wrong with taxonomic practice when error can persist so long, and when it takes more time and trouble to determine the name of a species than to elucidate its whole anatomy.

The root of the trouble lies, it seems to me, in our system of endorsement of specific names, which in its simplest and most general form has long ceased to authenticate the sense in which a given specific name is used. When Huxley (1851) wrote "*D. denticulatum*, Quoy and Gaimard," he meant, and conveyed his meaning, that he had

identified his specimens, rightly or wrongly, from Quoy and Gaimard's original account. The citation of the authors' names was no formality but a personal guarantee of authenticity. It was evidence of steps actually taken in the process of identification.

But when, thirty years later, Herdman (1888) wrote " *D. ehrenbergii*, Krohn," we know that he had not consulted Krohn's paper (1852), but took specific name, author's name, and the characteristics of the species from Uljanin's recently published Naples monograph (1884). The writing of the author's name meant nothing more than that Krohn was presumed (at second hand) to have been the original author of the name *ehrenbergii*. Originally a guarantee of authenticity, it had already become a mere piece of taxonomic ritual.

It should be noted, however, that Herdman had no option in the matter. The one brief superscription which would have correctly and intelligibly authenticated the species, as he regarded it, was " *D. ehrenbergii*, Uljanin," and if he had so written it, the mere fact of his omission of Krohn's name would probably have led to the discovery of his (and Uljanin's) error much sooner than was actually the case. But that formula would have contravened the rules of nomenclature, by which the specific name, if endorsed at all, must be endorsed with the name of its original author, whatever the changes which may subsequently have taken place in its connotation.

Nowadays, of course, when a species, as originally defined, has been enlarged or restricted or otherwise modified, it is the practice of good systematists to qualify the original author's meaning by one or more additional citations, and this practice is permitted, though not enjoined, by the Code. " *D. ehrenbergii*, Krohn, 1852 (emend. Uljanin, 1884)," however, as a title of a species, is unwieldy, as well as explicit, and additional citations of this order, being cumbrous when brevity is essential, are commonly neglected. It follows that, outside the works of monographic scope, the great majority of specific names in zoological literature lack any but the earliest authentications of their meaning, and with rare exceptions, unless the characters are given as well as the names, it is impossible in the case of variable or imperfectly known species to know with certainty what the writers intend by the names they use (e.g. *D. krohni* of Herdman, Borgert and Neumann respectively).

This difficulty, which has already involved immense confusion and the loss to science of thousands of conscientious records of distribution, must grow increasingly serious as zoological workers increase and disperse, while original descriptions become less and less accessible. As Dr. Calman recently told us in his survey of " The Taxonomic Outlook," " By far the greater part of this [i.e. systematic] literature is written by specialists for specialists, and much of it is unintelligible to any one else. From the time of Linnæus, however, there have not been wanting publications that have a different aim. We have monographs, synopses, revisions, of all sorts and sizes, attempting to render possible the identification of species without demanding a lifetime of study for each special group. The ideal for monographs would be, I assume, that

they should be intelligible to, and render possible the determination of species by, any properly trained zoologist, even without previous experience in dealing with the particular groups of which they treat." (Presidential Address, Sect. D, Brit. Ass., Bristol, 1930).

This being the state of affairs, the question arises how zoologists, who wish by means of the Linnean system of nomenclature to be understood by their fellows, are to authenticate the names they use with the maximum of brevity and precision. It cannot be assumed that every one will use the same monograph, synopsis or revision for any particular group, and it is only too apparent that different monographers have their own systems of " one and only valid names." Moreover, many of these zoologists may be expected to have preferences for one monographer as regards one section of the group and another for another, with endless variations in the extent to which they may exercise their own judgment in cases of uncertainty. *Ex hypothesi* they are no longer expected to verify the monographers' results from the original sources, but they may occasionally be able to do so. Citation of original authors may, therefore, in some cases imply consultation, in others not. The one and only thing they all can honestly do is to cite the name of the author whose account they have followed in any particular case, and that is the one and only endorsement that is essential for mutual understanding.

If, on the other hand, they do not cite their selected authority, but simply quote him, as Herdman quoted Uljanin, without a corresponding endorsement, they will have obeyed the existing rules of nomenclature ; but, as likely as not, be the cause of further confusion to other zoologists who succeed them.

In conjunction with the evidence recorded in my critical survey above, sufficient has been said, I think, to justify a plea for a revision of the International Rules which govern the endorsement of zoological names (Art. 21–24). Where brevity is essential —as it is in local lists, records of distribution, and most publications other than monographs and systematic revisions—a single author's name is all that can be afforded. A name, even if right, which is borrowed at second hand from some other author has obviously no value as a guarantee either of authenticity or priority. On every count I urge that the single author's name to be cited should be that of the authority actually followed by the writer. It is his description only, not that of the original author, which guarantees the meaning of the *nomen triviale* selected by the writer. The original authorship of such names is history, not science, and its safeguarding can confidently be entrusted to the monographers.

V. OLD NURSES.

(*a*) CLASSIFICATION BY MUSCLES.

With few exceptions, the possibility of distinguishing the species of "old nurses," i.e. of oozooids which have lost their viscera, by means of definite structural characteristics, has been given up as hopeless. Here and there the capture of old nurses in association with some particularly abundant type of gonozooid or phorozooid has seemed to justify reference of the nurses to the same species, but, unless the nurses so named can be given specific characters of their own, there is no means of identifying them when they present themselves under other conditions.

The most hopeful plan appears to be to proceed by means of a perfectly independent classification of them, leading to a progressive differentiation of their characters. Individual forms can then be related from time to time, on the one hand, to young nurses, and these to their parental types of gonozooid, or, on the other, to the phorozooids which they themselves produce and carry. The former method in Grobben's hands gave rise to our knowledge of the old nurses of *mülleri* and (probably) *denticulatum*, the latter in Gegenbaur's and Neumann's to the recognition of at least the general characters of *gegenbauri*. But no attempt has yet been made to assign characters by which an old *mülleri* can be distinguished from an old *gegenbauri*, or a young *denticulatum* from the early stages of the others.

According to their musculature, however, old nurses can be arranged in the three following groups :—

1.—Narrow-banded (Nb), e.g. Neumann's *resistibile ;*

2.—Broad-banded (Bb), e.g. *mülleri, rarum, gegenbauri ;* and

3.—Continuously coated or cuirassed (Cc), e.g. *denticulatum.*

Or, to use a series of technical words, with their appropriate definitions :

1.—Stenomyonic—muscle-bands narrower than half the interspaces ;

2.—Eurymyonic—muscle-bands broader than half the interspaces ; and

3.—Holomyonic—muscles 2–8 united into a continuous sheet.

The definitions of (1) and (2) are arbitrary, but, I think, sufficient. A eurymyonic or holomyonic nurse passes through a stenomyonic stage, but the limit selected is applicable to both *mülleri* and *denticulatum* in at least the later stages of their "young nurse" condition, before atrophy of the alimentary viscera, and is fully applicable to them when this process is complete (see Grobben's figures, l.c. Taf. I–III).

As our knowledge progresses the banded species may become distinguishable from one another by the actual width of the muscles in relation to the interspaces at successive stages of growth, but there is little likelihood that dimensions of the muscles in themselves will be of much use. In July, 1900, during his interesting cruise in the Bay of Biscay in H.M.S. "Research," Dr. G. H. Fowler (1905, l.c.) struck a great swarm of oozooids ("blastozooids" in his account, after Herdman), and collected nearly 500.

The great majority (369 out of 456) were very small, under 3 mm., and many still retained their internal organs. As already remarked (p. 218), I believe Fowler had excellent reasons for identifying these early stages with *D. tritonis*. His assumption that the old nurses (3–9 mm.) taken with them were also referable to *tritonis* was perhaps not unnatural. But, with admirable foresight, as possibly diagnostic of his species, he published a record of the width of the 4th muscle in 50 specimens of various size. As explained more fully below, I believe that I can now separate the most widespread types of broad-banded nurse, *gegenbauri* (=*tritonis*) and *mülleri* (probably =" *krohni* "), from one another. Some averaged measurements of M_3 and M_4 from my extracted species are included in the following table, together with a copy of Fowler's " means " (modes ?) of M_4 from his suggested *tritonis*.

Length (mm.)	M_3			M_4			
	D. mülleri	*D. gegenbauri*		*D. mülleri*	*D. gegenbauri*		*D. tritonis (?)*
	S. Pac.	S. Pac.	S. Atl.	S. Pac.	S. Pac.	S. Atl.	N. Atl.
	28	14	16	28	14	16	50 specimens (Fowler)
3	0·46	0·55	—	0·54	0·53	—	0·27
4	0·60	0·66	—	0·68	0·66	—	0·50
5	0·78	0·80	—	0·87	0·80	—	0·57
6	0·88	0·97	0·97	0·98	0·96	0·85	0·81
7	0·96	—	1·38	1·09	—	1·00	0·88
8	—	—	—	—	—	—	—
9	—	1·62	(1·60)	—	1·57	(1·45)	—
10	—	—	—	—	—	—	—
11	—	—	(1·80)	—	—	(1·60)	—
12	—	—	2·00	—	—	1·85	—
13–15	—	—	2·65	—	—	2·35	—
16	—	—	—	—	—	—	—
17–18	—	—	3·02	—	—	2·78	—

TABLE III, showing the approximate width (mm.) of M_3 and M_4 in successive size-groups (mm.) of old nurses, suggested as being *D. mülleri* and *D. gegenbauri* by the author, and *D. tritonis* by Fowler. (Isolated measurements in brackets.)

It will be seen that my figures for *mülleri* form very good series for each of the muscles, the increments (14, 18, 10, 8, for M_3, and 14, 19, 11, 11 for M_4) following a curve of growth quite normal for a small species. The two local samples of the larger *gegenbauri*, though based on regrettably small numbers, are almost equally harmonious. The two *mülleri* series closely approximate to the early stages of *gegenbauri*, but are slightly higher throughout for M_4, and lower in the case of M_3, for reasons which will appear later.

Fowler's series, on the other hand, is very uneven, in spite of being based on two or three times my numbers; and the increments follow no possible curve of growth (23, 7, 24, 7). It follows, I think, that Fowler's swarm must have been a mixture of at least two species, one with broad, the other with much narrower muscle-bands, probably *tritonis* or *mülleri* on the one hand, possibly both, and *D. rarum* or even *mirabilis* on the other.

In any case comparison of the figures reveals the uselessness of isolated measurements of M_4, and even of M_3 (which would have been a better choice) for the discrimination of specimens of the two species.

The relation of individual muscle-width to interspace-width is not easy to use with confidence on preserved material, as the natural relations are disturbed by a variety of conditions. I have tried extensively a modification of this relation by expressing the total muscle-widths (either M_1–M_9 or M_2–M_8) as fractions or percentages of the total body-length, and found the relation useful, but not always reliable in critical individual cases.

Other characters can also be drawn in, viz. the position of the otolith, brain, and stolon in their respective interspaces, the size of brain and otolith in relation to the size of the body, and peculiarities in the shape of the blastophore.

(*b*) IDENTIFICATION OF *GEGENBAURI* AND *MÜLLERI*

The most fruitful method, however, in dealing with the "Terra Nova" material was to measure the width of all the muscle-bands in a sufficient number of specimens, express these as percentages of the total muscle-width, and look for signs of special agreement or difference in the arrays presented. This method overcame the difficulty of comparing the muscles in specimens of different size, and minor irregularities due to condition could readily be smoothed out by averaging the dimensions yielded by several specimens of similar size and appearance.

By this method the homogeneity of the collections of old nurses from the S. Atlantic stations 40–50 was readily demonstrable, for almost every specimen of whatever size showed a predominant width of M_3, and every specimen showed a predominance of M_3 and M_4 together, over the combined widths of any other adjacent pair. The great size of some of these nurses (<18 mm.) left no doubt that we had to do here with *Dolioletta gegenbauri* either in its typical or varietal form *tritonis*, although not a single gonozooid or phorozooid of this or any other species was collected on the same occasions.

On passing to the more heterogeneous collections from New Zealand waters, difficulties ensued from the predominance of small specimens and the slightness of the differences between the muscle-widths of different stations, complicated as they were by great differences in condition. As a mixture of species was to be expected, and no clear line of differentiation was visible, the first step was to arrange the data according to size-groups, without any other selection.

The results are shown in the following table, which gives the Atlantic and Pacific percentages side by side for comparison :—

No.	Range	Mm.		Muscle-widths as Percentages of Total Muscle								
		Average length	Average total M	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9
Atl. 7	6–7	6·7	5·1	2·6	10·5	**19·7**	**18·3**	15·1	13·8	11·4	5·6	3·0
6	9–15	12·1	10·3	2·8	10·8	**20·6**	**18·5**	15·1	14·1	10·4	5·2	2·7
3	17–18	17·3	14·7	2·5	10·7	**20·5**	**18·9**	15·1	14·2	10·7	4·7	2·6
16	6–18	—	—	2·7	10·6	**20·3**	**18·6**	15·1	14·1	10·7	5·2	2·8
Pac. 21	3–4	4·0	3·4	2·0	11·5	15·8	**17·4**	**16·8**	15·2	12·0	7·2	1·9
23	5–6	6·0	5·2	2·1	11·3	**16·4**	**17·4**	**16·5**	15·1	12·2	7·4	2·1
8	7–9	7·8	6·7	2·2	11·1	**17·1**	**18·0**	16·5	14·1	11·6	7·0	2·3
52	3–9	—	—	2·1	11·3	16·3	**17·5**	16·6	14·9	12·0	7·2	2·1

TABLE IV, showing the percentage ratio of muscle-widths to total muscle for various size-groups of Atlantic (Atl.) and Pacific (Pac.) old nurses (without other selection).

It will be noticed that in the Atlantic series not only do M_3 and M_4 retain a marked predominance in each size-group, but the percentage values deviate less than 0·5 per cent. from the mean, in spite of a great range of size in the specimens examined (6–18 mm.), and of very limited numbers. The specific homogeneity of the population is thus unquestionable.

In the Pacific seas, on the other hand, instead of constancy in these relations, the smallest size-group shows a marked preponderance of M_4 and M_5, the largest group a preponderance of M_3 and M_4, and the intermediate size-group an intermediate character, with a preponderance of M_4 and relative equality of M_3 and M_5. This combination of features seemed to point to a mixture of two types, a large race in which M_3 and M_4 preponderated, and a small one in which M_4 and M_5 were widest, thus yielding on combination a preponderance of M_4.

Other particulars were noted while the measurements for these calculations were being made, since the size of the brain and otolith, it was thought, might also be useful; but in very many specimens the otolith, and in a few even the brain, could not be detected. This was at first attributed to the fact that both lay under the muscles, which in many, if not most, cases were so distorted and wrinkled that concealment of these organs was not surprising. To make certain, therefore, special dissections and preparations were made to expose the otolith, even macerations and serial sections,—in the great majority of cases with no result except to confirm its absence. On the other hand, a fine otolith was always to be found in the Atlantic nurses, so that the startling idea of a new species without an otolith had to be entertained.

My records showed that the stations were not all alike in the proportion of specimens lacking otoliths, stations 111–114 being particularly defective, station 142 less so.

Accordingly the measurements were rearranged for station 142 in two groups, those with and those apparently without an otolith, with the following astonishingly clear result :—

Otolith	No.	Length (mm.)		T. M.	Muscles as Percentages of Total Muscle								
		Range	Average		M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9
+	6	3·8–9·7	6·08	5·25	4·1	9·8	**17·8**	**17·6**	15·3	14·5	11·3	6·4	3·3
—	10	4·2–9·0	6·31	5·58	2·1	10·9	16·5	**17·7**	**16·8**	14·9	12·0	6·9	2·4

Table V, showing for station 142 the percentage ratios of muscle-width to total muscle in old nurses with (+) and apparently without (—) otoliths.

By selecting, in fact, according to the mere presence or absence of an otolith, two groups with definite muscular peculiarities had now been extracted independently of size; and in one not only were M_3 and M_4 the widest muscles, but M_3 was on the average slightly wider than M_4, as in the Atlantic species.

Not only so, but, through the kindness of Professor J. P. Hill, I have been enabled to examine a series of preparations he made of Doliolid nurses at Sydney, N.S.W., all possessing otoliths, and measurement of their muscles revealed the closest possible agreement with the first of the two sets of figures, as well as with the S. Atlantic values. It was thus clear that in these three regions we had to do simply with local populations of one and the same species.

This agreement becomes even clearer if we remove from the New Zealand series the only one of the six specimens which individually fails to show the typical muscular characters, viz. equality and preponderance of M_3 and M_4, with a tendency for M_3, but not M_4, to predominate over its partner. The body-length, total muscle, and nine individual muscle-widths of this specimen were as follows (all in mm.) :—

L.	T. M.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
5·8	4·47	0·20	0·50	0·70	0·75	0·70	0·70	0·50	0·30	0·12

The accompanying table shows the revised percentage figures for the New Zealand specimens, together with those for the Australian and S. Atlantic series :—

	No.	Length (mm.)	Width of Muscles as Percentage of Total Muscle								
			1	2	3	4	5	6	7	8	9
N.Z. ..	5	3–9	4·0	9·6	**18·1**	**17·8**	15·2	14·2	11·2	6·3	3·4
Aus. ..	8	2–6	1·8	9·9	**18·3**	**18·3**	16·2	14·9	12·0	6·2	2·4
Atl. ..	16	6–18	2·7	10·6	**20·3**	**18·6**	15·1	14·1	10·7	5·2	2·8

Table VI, showing relative width of muscles of *Dol. gegenbauri* oozooids from New Zealand, Australian, and S. Atlantic waters.

The irregularity in the figures for the terminal muscles M_1 and M_9 is simply due to different states of contraction and condition. Acting as sphincters, these muscles, when contracted in a healthy state, are seen only in profile, and yield small figures upon measurement, which in reality record their thickness, not their width. Specimens in bad condition show these muscles in a variety of postures, often completely relaxed. Hence the unconscious tribute which the New Zealand specimens pay to Professor Hill's excellent preparations. It would be easy and permissible to exclude these muscles from the survey, but the error they introduce only amounts to 2 or 3 per cent. The application of a correction would, of course, bring about a still closer assimilation of the New Zealand to the S. Atlantic percentages in the case of the larger muscles.

Returning now to the more mysterious question of the specimens without otoliths, the possibility of relating these as a whole to one of the other species collected by the "Terra Nova," was limited to the choice of *D. mülleri* and *D. mirabilis*. Apart from the otolith question, the probabilities were all in favour of *mülleri*, since larval oozooids, with the characteristic *Doliolina* gut, were repeatedly taken, while the distribution and number of old nurses was out of all proportion to the single swarm of *mirabilis* phorozooids. Having early measured the muscles in Grobben's camera drawings of *mülleri* (l.c. Pl. III), and reduced them to percentages, a certain resemblance to those of the otolith-less specimens of station 142 was obvious, but not close enough to be convincing. In Grobben's figure of his largest specimen (3·8 mm. from M_1–M_8), M_4 undoubtedly stands out conspicuously from its neighbours as it does in Table V, but Uljanin's figures (1884, VIII, 10; IX, 6) show no such predominance. The few young nurses with *Doliolina* gut found in the collections, like the figure of Grobben's youngest stage (fig. 17) also showed no special widening of this muscle, but a tendency to a bipolar symmetry of the muscles and body as a whole on either side of a median cross-plane through the 4th interspace. This condition was so common in my records of measurements that it seemed worth while to repeat the experiment of elimination, which had been made with the otolith-bearing group, but in the opposite direction, viz. of excluding from the unotolithed class three records which were at variance with the majority, and tended in the *gegenbauri* direction. The results of this analysis of the (−) series in Table V are given in the following table (VII), to which, for comparison I have added (1) the combined percentage values of the muscles in Grobben's three figures of *mülleri*, and (2) corresponding figures for the four "Terra Nova" larval oozooids (young nurses).

To complete the case for identification I then give in a separate table (VIII) the actual measurements of all the small nurses (<3 mm.) from station 113, and of some others which had been identified as *mülleri* from Grobben's figures (St. 86, 92, and Miss Webb's under *Incert. sed.*), and have arranged these in descending order of their "Total Muscle," inserting the calculated figures for Grobben's two old nurses of *mülleri* (figs. 17, 18) in their places in the sequence.

Data	Range (mm.)	L.	T. M.	Muscle Percentages (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
The 3 nurses removed (*gegen.*)	5·2–9·0	6·6	6·2	2·7	10·4	**18·2**	**17·7**	15·5	14·2	11·5	6·7	2·9
The 7 left	4·2–7·2	6·0	5·3	1·8	11·0	15·5	**17·6**	**17·3**	15·2	12·2	7·0	2·1
Grobben's figs. 17–19 (*mülleri*)	1·4–3·8	2·5	1·44	2·1	10·6	15·1	**17·4**	**17·3**	16·3	12·7	6·9	1·7
4 "Terra Nova" larval Oozooids (*mülleri*)	1·1–1·5	1·25	0·49	4·6	9·3	14·1	**17·2**	**17·2**	14·9	12·7	6·6	3·6

Table VII, showing for st. 142 the result of extracting 3 *gegenbauri*-like nurses from the group without otoliths. Data of young *mülleri* nurses added for comparison.

Data	Mm. L.	T. M.	Width of muscles in mm. M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9
St. 86	3·35	3·00	0·05	0·32	0·45	**0·50**	**0·50**	0·45	0·41	0·27	0·05
Grobben's fig. 18 ..	3·80	2·90	0·06	0·34	0·45	**0·50**	**0·46**	0·46	0·37	0·23	0·03
St. 113	2·95	2·46	0·02	0·28	0·38	**0·45**	**0·42**	0·38	0·30	0·20	0·03
Inc. Sed. (2) (Miss Webb's)	3·75	2·39	0·10	0·30	**0·35**	**0·40**	**0·35**	0·32	0·30	0·20	[0·07]
St. 113	2·60	2·02	0·04	0·25	0·30	**0·33**	**0·35**	0·30	0·22	0·18	0·05
,, ...	2·40	2·02	0·04	0·25	0·30	**0·35**	**0·33**	0·30	0·25	0·15	0·05
,, ...	2·15	1·66	0·03	0·18	0·25	**0·28**	**0·29**	0·25	0·20	0·15	0·03
,, ...	1·88	1·26	0·03	0·13	**0·20**	**0·20**	**0·20**	**0·20**	0·17	0·10	0·03
,, ...	1·60	1·20	0·03	0·08	0·18	**0·20**	**0·20**	**0·20**	0·17	0·11	0·03
St. 92	2·00	1·06	0·04	0·10	0·15	**0·18**	**0·18**	0·15	0·15	0·08	0·03
Grobben's fig. 17 ..	2·20	0·94	0·02	0·07	0·12	**0·17**	**0·18**	0·15	0·14	0·07	0·02
Inc. Sed. (i)	1·50	0·56	0·02	0·05	0·07	**0·10**	**0·10**	0·08	0·08	0·04	0·02
Totals	30·18	21·47	0·48	2·35	3·20	3·66	3·56	3·24	2·76	1·78	0·44
Averages	2·51	1·79	0·04	0·20	0·27	0·30	0·29	0·27	0·23	0·15	0·04
Percentages of Total Muscle			2·2	10·9	14·9	**17·1**	**16·6**	15·5	12·9	8·3	2·0

Table VIII, showing muscle measurements (mm.) of the smallest old nurses from st. 113 and others directly identified as *mülleri*, compared with Grobben's figures of *mülleri*. (Specimens arranged in descending order of Total Muscle-width.)

It will be seen that the three specimens removed possess the same characters as the previous otolith-bearing series, the percentage figures being almost identical with those of *gegenbauri* in Table VI, except as regards the variable sphincters. The remaining seven yield a series of figures which fit the averages for Grobben's figures of *mülleri* and of the young *mülleri* oozooids of the "Terra Nova" to a nicety. The evidence of

unbroken continuity between young and old, as well as data concerning the amount of variation, are given in Table VIII.

It follows that the absence of an otolith from all these specimens was not a real distinction, but marked an accidental or a pathological condition. A closer scrutiny of specimens under the microscope revealed a series of features which left no doubt that the vast majority of the otolith-less specimens must already have been dead and decaying when collected. Not only was the brain absent, misshapen, or displaced, in a number of specimens, but the fine nerves radiating from it in good specimens were completely lacking.

These preceding remarks have all referred to the 16 old nurses from station 142, where, as we have seen, there was a mixture of two species—8 *gegenbauri*, all but 3 with otoliths, and 8 *mülleri*, all but 1 without otoliths—for the single specimen removed from Table V, whose characters have been given, clearly falls into the *mülleri* series. Only half the total collection (33) from this station was analysed in this way, but the only criterion of selection was suitability of the specimens for measurement, some specimens being much contorted, others mutilated. There can be no doubt that the sample examined was representative of the whole, so far as the question of species is concerned.

On the other hand, only 2 or 3 of the 40 old nurses from stations 111–114 possessed recognisable otoliths, and the remainder, treated in the same way, show the most remarkable uniformity. The percentages averaged for all the specimens from any one station are astonishingly similar to those from the other stations; and, when amalgamated as a whole, and redivided into size-groups, the agreement is undisturbed, as shown in the accompanying table.

Station	No.	Length (mm.)		T. M. (Av.).	Muscle Percentages								
		Range	Average		M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9
111 ..	16	3–7	5·21	4·42	1·7	11·8	15·8	**17·6**	**16·9**	14·9	12·0	7·4	1·7
112 ..	4	5–7	6·67	5·58	1·5	11·4	16·3	**17·0**	**16·8**	15·2	12·5	7·6	1·6
113 ..	14	3–5	4·35	3·79	1·6	11·9	15·6	**17·1**	**16·8**	15·1	12·3	7·7	1·7
114 ..	5	4–8	5·70	4·89	1·8	11·6	16·4	**17·6**	**16·8**	15·1	12·3	7·2	1·7
111–114 ..	39	3–8	5·11	4·35	1·6	11·8	15·9	**17·4**	**16·8**	15·0	12·2	7·5	1·7
Do. (small)	20	3–4	3·97	3·34	1·7	11·6	15·5	**17·5**	**17·1**	15·2	12·1	7·5	1·7
Do. (large)	19	5–8	6·31	5·41	1·5	11·9	16·1	**17·4**	**16·7**	14·9	12·2	7·5	1·7

TABLE IX, showing the muscle percentages of old nurses devoid of otoliths at stations 111–114, separately and together, and in two size-groups (*Dol. mülleri*).

The resulting figures, moreover, are practically identical with those of *mülleri* from station 142, so that the result is unequivocal. Except one of the specimens with an otolith, which differed in other respects (see Records, st. 111, below), the whole of the old nurses from stations 111–114 belong to *Doliolina mülleri*, and the great majority were in a more or less decayed condition.

(*c*) NURSES WITHOUT OTOLITHS.

The loss of the otolith in *Doliolina* and the rarity or absence of the phenomenon in *Dolioletta* and *Doliolum* are doubtless to be correlated with the known differences between these types in the constitution of the organ. The membranous pellicle which forms a thin cupola over the superficial otolith of a *Doliolina* may be expected to give way more readily than the invaginated epithelial sac which lodges the otolith in *Dolioletta* (cf. Uljanin, l.c. pp. 56, 57, Taf. I, figs. 11, 12). The presence of an otolith in these forms, therefore, does not necessarily imply a healthy condition ; but its loss in *Doliolina* is an early indicator of death and decay. It is interesting to note that the two old nurses of *Doliolina resistibile*, a very different species, which were taken by the " Terra Nova " within the Antarctic Circle, also lacked otoliths, though otherwise apparently in remarkably good condition (see p. 55).

The facts and conclusions here presented have obvious bearing on the question whether old nurses dragged up from the ocean depths are really living there, or merely " surviving as corpses " in ice-cold regions where neither " moth nor rust (bacteria) can corrupt." Neumann, if I understand rightly his use of " befähigt " and " aufsuchen," regards the abundance of old nurses in the depths of the sea, and their relative scarcity at the surface, as an indication of their having a preference for the lower regions and for the cooler waters they find there (1906, p. 240). The loss of the otolith, however, seems hardly likely to be a bathyplanktonic adaptation, even if the question of their food supply could be met.

In this connection some observations and an experiment of my earliest teacher in Zoology, the late Professor H. N. Moseley, may be recalled. With reference to the " rain of food " upon the bed of the ocean, he wrote :—

" It might be supposed that these shells and other surface animals would consume so long a time in dropping to the bottom in great depths that their soft tissues would be decomposed, and that they would have ceased to be serviceable as food by the time they reached the ocean bed. Such is, however, not the case, partly because the salt water of the sea exercises a strongly preservative effect on animal tissues, partly because the time required for sinking is in reality not very great.

" In order to test the matter for myself I made the following experiment. I took a dead Salpa, of about 2 inches in length, and placed it in a glass cylinder full of water, and 3 inches in diameter. I allowed the Salpa to fall from the surface of the water in the cylinder to the bottom a number of times, and noted carefully the time which it took to traverse this distance, which was about 8 inches. I found that on an average it took 20 seconds to fall the 8 inches. This gives at the same rate, without allowance for acceleration, a distance of a fathom to be traversed in three minutes, or 2,000 fathoms in four days four hours.

"I allowed the Salpa to remain in the sea water in the cylinder for a long time. It was still not greatly decomposed after having remained in the same water for a month, whilst the ship was in the tropics; the nucleus was after this interval still undestroyed. The dead animal might have thus sunk to the bottom in the greatest depths almost six times over without having become so much decomposed as to be unserviceable for food to deep-sea animals." (Notes by a Naturalist on H.M.S. "Challenger," p. 505.)

The *resistibile* nurses were taken in a vertical haul from 0–500 metres; but the objection may well be urged that the New Zealand old nurses were collected in surface nets with numbers of healthy and active organisms, including delicate Doliolid larvæ. A glance, however, at the position of the stations concerned, as described in the "Records" which follow (pp. 243–249), and at any chart of depths of Australasian waters, shows that the "Terra Nova" collections were made above a relatively narrow submarine ridge connecting New Zealand with Norfolk I. to the N.W., and that the sea on either side descends to great depths, particularly on the outer side, facing the Pacific. On the southern side a broad arm of the Southern Ocean, over 2,000 fathoms deep, separates the South Island of New Zealand from Tasmania and S.E. Australia. These conditions are ideal for an upwelling of deep waters under the influence of surface currents, and I cannot hesitate in ascribing the irruptions of these dead and decaying oozooids to this cause.

It will be noticed in the "Records" that the July survey of Kings Passage (st. 80–93) yielded many swarms of *denticulatum* gonozooids, with an occasional *gegenbauri*, but no oozooids except the smallest, indubitably pelagic, stages, and during the first week of August the conditions over the base of the "Ridge" were unchanged. This means that the appearance of the old nurses in August was an invasion. Their first irruption was associated with a large, but casual, swarm of *mirabilis*, phorozooids (st. 111, August 7) with a marked invasion of healthy *mülleri* larvæ, and with the only phorozooids (or gonozooids) of this species obtained during the whole expedition (st. 113, August 9). The second irruption, a month later (st. 142, September 8), was accompanied merely by *débris* of the *mirabilis* swarm, and no *mülleri* larval forms, though the *mülleri* old nurses were of the same size and in the same condition as before. The collections were made, however, 100 miles nearer to the Australian deepwater, and for the first time included *gegenbauri* nurses as well, which we have seen, from Professor Hill's collection, may be plentiful, and apparently healthy, in the water of Sydney Harbour, and for which the Barrier Reef expedition has recently provided a record for the N.E. coast of Australia (Hastings, 1931, p. 106, as *tritonis*).*

No sure picture can be drawn from these fragmentary data. The *mülleri* of these waters is identical with the variety *krohni* of Borgert (cf. st. 113, p. 247), a form which, owing to its wide distribution, may have come from the south or the north. But *mirabilis* is definitely a tropical and subtropical species, and must have invaded the area from the north.

* Dr. Hastings tells me that a catch at st. 34 on Dec. 19, 1928, consisted entirely of typical *gegenbauri*.

An upwelling of deep waters on the northern edge of the slope, under the influence probably of a current from the N. or N.E. would account for all the phenomena.* The possibility of a second upwelling on the southern side from the deep Australian Bight of the Southern Ocean has little to support it.

(*d*) EARLY STAGES OF *D. DENTICULATUM.*

The ability to distinguish now between the old nurses of *mülleri* and *gegenbauri* encourages the belief that other species will prove amenable to similar methods, and, of course, biometric methods are capable of considerable refinement. I had hoped to be able to show how the eurymyonic stages of *denticulatum* can also be differentiated, but my work on this species is not yet ripe for publication, and I am reluctantly obliged to reserve it.

In the meantime I may remark that in the "Terra Nova" material I came across two young Doliolid oozooids, one from the Atlantic and the other from the Pacific, which differ greatly from the young stages previously attributed to *denticulatum* in the extreme shortness of their endostyles, which extend only between M_2 and M_4 (Ooz. A_1 and A_2, 1·85 and 2·5 mm., st. 70, 83). In this, as in other respects, they closely recall two figures of Keferstein und Ehlers, though the endostyle is even shorter than there represented (1861, Taf. X, figs. 2, 4). In both the young nurse stages of Grobben's *denticulatum* (1·4 and 2·2 mm. long, from M_1 to M_9) the endostyle stretches almost from M_2 to M_5.

Owing to the characteristic shortness of the endostyle in the gonozooids of *denticulatum,* I am strongly inclined to refer these young "Terra Nova" oozooids to this species, and to suggest that Grobben (who recognised no Mediterranean species other than *mülleri, rarum,* and *denticulatum*) included young stages of *gegenbauri* by mistake. It is noticeable that in his drawings of the two metamorphosing stages of *denticulatum* (figs. 4, 5), M_3 and M_4 predominate as I have shown them to do in *gegenbauri.*

(*e*) RELATION OF OOZOOIDAL TYPES TO THE SYSTEM.

The establishment of a distinction between the oozooids of *Doliolina mülleri* and *Dolioletta gegenbauri* removes the only outstanding anomaly between the rough classification of oozooids outlined at the beginning of this chapter (p. 229), and the system of Doliolids as revised at the outset (p. 201). It is now clear that the eurymyonic condition has been acquired independently in the two cases, and the distinction can be clinched by terming that of *mülleri* "mesozonal," and that of *gegenbauri* "prozonal," with reference to the position of the zone of maximum muscle-width. In one this zone lies very close to the middle of the body, in the other definitely in the anterior region.

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* "Hereabouts rather troubled waters prevail, as the swell from the Tasman Sea to the West meeting that from the Pacific to the East often causes a confused swell even in calm weather. . . . On unsuitable days, if the wind was easterly, nothing could be done except to heave to and drift." (Extract from *Scott's Last Expedition*, arranged by Leonard Huxley, II, pp. 396–7.)

The outstanding pairs of muscles, viz. M_3 and M_4 in the prozonal type, or M_4 and M_5 in the mesozonal type, are of course only part of a series of muscle-rings functioning in relation to one another.* A complete exposition of the difference of type would take all the muscles into consideration. They form a doubly graduated system with a climax towards the middle and a gradient on either side which diminishes in opposite directions—a system which, in this case, may conveniently be termed the "Myocline," and the type an "Amphicline." By revealing the preponderance in the two species of two different pairs of muscles, we have in fact defined the position of the climactic plane of the amphicline, which separates the two gradients—a plane which, though a pure abstraction, it is essential for precision to recognise and define, and which, without a blush for the barbarism, I propose to designate the "Myoplane."

For descriptive purposes, accordingly, we give a fuller and more accurate diagnosis of the muscular systems of these two species if we describe that of *mülleri* as "amphiclinous, with the myoplane midway between M_4 and M_5," and that of *gegenbauri* similarly, but with the "myoplane between M_3 and M_4,"—more tersely still, *mülleri* with "myoplane $4\frac{1}{2}$," *gegenbauri* with "myoplane $3\frac{1}{2}$."

The previous adjectives—mesozonal and prozonal—are qualitative terms, which require no measurements for their application; the terms just given are quantitative, and, while applicable upon mere inspection, are also capable of considerable refinement when biometric methods are practicable.

A tendency is recognisable in each case for the myoplane to shift forwards with increasing length of body, so that instead of the paired muscles remaining sensibly equal, as well as dominant, the anterior member of the pair outstrips its fellow. It is then a matter of indifference whether this condition is described as "M_3 distinctly widest" or "myoplane 3." Were a distinct predominance of M_3 to characterise some variety or species throughout life, the condition might be distinguished from the Prozonal type as "Tritozonal," and a dominance of M_4 similarly as "Tetartozonal."

The state of our knowledge as to the character of the oozooids in the various genera, when fully differentiated, may now be summarised as follows:—

Doliolina mülleri, Kr. (including *krohni*, Borgert, *non* Herd.) Eurymyonic, amphiclinous, mesozonal, Myoplane $4\frac{1}{2}$.

D. intermedium (Neum.), *sens. lat.* (including *resistibile*, Neum.). Stenomyonic, aclinous.

D. krohni, Herdman (*non* Traustedt, Borgert, Neumann).
D. indicum, Neumann.
D. sigmoides, Garst. (=*krohni*, Neum. p.p. *non* Borgert).
} Unknown.

* According to Fedele (1923), the movements of the gonozooids and young nurses of *D. mülleri* are by jerks in either direction. The body-muscles all contract simultaneously, and the direction is determined simply by the closure of one or other of the sphincters. These, however, are stenomyonic forms, and it remains to be settled whether the eurymyonic condition is not accompanied by a normal habit of progression forwards, which is likely to be especially marked in forms with an anterior position of the climactic plane and an elongated body, such as *gegenbauri*.

Dolioloides rarum, Grobben.
Eurymyonic, aclinous (?).
Dolioletta gegenbauri, Uljanin (including *tritonis*, Herd.).
Eurymyonic, amphiclinous, prozonal, Myoplane, $3\frac{1}{2}$–3.
D. valdiviæ, Neum. } Unknown.
D. mirabilis (Korot.) Fedele. }
Doliolum nationalis, Borg.—Unknown.
D. denticulatum (Q. and G.), Neumann (including *ehrenbergii*, Krohn, *non* Herdman). Holomyonic.

VI. SYSTEMATIC SUMMARY AND RECORDS OF DISTRIBUTION.

(*a*) SYSTEMATIC SUMMARY.*

FAM. DOLIOLIDÆ. †

1. *Doliolina* (Borgert), *sens. restrict.*

1. *D. mülleri*, Krohn (1852), var. *krohni*, Borg. (as sp., 1894), *non* Herd. 1888.

GZ and PZ.—St. 113 (PZ).
OZ.—St. 86, 92, 111, 112, 113 (Larvae, etc.), 114, 142, 143, *Inc. sed.* (1) (2).

2. *D. intermedium* (Neum.), *sens. lat.* var. *resistibile*, Neumann (as sp., 1913).

OZ.—St. 178.

2. *Dolioletta* (Borgert), *sens. restrict.*

3. *D. gegenbauri*, Ulj. (GZ), Neumann (OZ) ; *sens. lat.*

GZ and PZ.—St. 1 (var. *tritonis*), 70, 83, 84, 92, 93, 107, 143.
OZ.—St. 40, 46, 47, 50, 107, 111 (?), 113 (?), 142.

4. *D. mirabilis* (Korotneff), Fedele (1923).

GZ and PZ.—111, 113 (?), 126, 142 (?).
OZ.—111 (?), 126 (?).

3. *Doliolum* (Q. and G.), *sens. restrict.*

5. *D. denticulatum* (Q. and G.), Neumann (1913, *Das Tierreich*).

GZ and PZ.—St. 61, 63, 70, 83, 84, 85, 86, 92, 106, 107, 109, 111, 113, 114, 126, 143, *Inc. sed.*
OZ.—70 (?), 83 (?), 107, 111, 112, 113, 114, 142.

(*b*) RECORDS OF DISTRIBUTION.

In the arrangement of this record the plan adopted by Harmer and Lillie in their "List of Collecting Stations" (British Antarctic "Terra Nova" Expedition, Zool. II, 1, 1914) has been followed, but with some subdivisions of the main areas. The stations

* For abbreviations of terms, see p. 250.

† The family Doliopsidæ, including at present only *Doliopsis*, Vogt (= *Anchinia*, Esch.) was not represented in the collection.

sampled (both Plankton and Benthos) are there arranged in four geographical areas, each area having a separate plate to show the position of the stations, as follows :—

Plate I. Atlantic. Stations 1–70. (All Plankton except 20, 22, 36–38, and 42.)
,, II. S. Pacific, New Zealand Waters, between 32° and 36° S. Stations 71–150. (All Plankton except 90, 91, 95, 96, 134, 144, 149 and 150.)
,, III. Southern Ocean, S. of 36° S.
S. African sector. St. 151–155. (No Plankton.)
Australian sector. St. 156–161. (1 Plankton.)
New Zealand sector. St. 162–307. (129 Plankton.)
S. American sector. St. 308–311. (All Plankton.)
,, IV. McMurdo Sound, 76° S.–78° S. (23 Plankton stations.)

Except from one station in Area III (St. 178), no Doliolids were received from Areas III and IV.

AREA I.—ATLANTIC.

I. a. *Off Mouth of English Channel.*

St. 1. 48° 21′ N., 9° 58′ W. June 17, 1910. Dipped up with bucket.
Dolioletta gegenbauri, var. *tritonis*. 1 GZ, 9 mm.

I. b. *Madeira and Canaries.* 5 Plankton stations. June 25–30.

No Doliolids received.

I. c. *South Atlantic between Rio and Trinidad Island.* 18° S.–23° S. April 27–May 7, 1913. 11 Plankton stations, 7 with no Doliolids.

St. 40. *Dol. gegenbauri.* 3 OZ(Bb), 7 mm., firm, one fully expanded and barrel-shaped.
St. 46. *Dol. gegenbauri.* 20 OZ(Bb), flat, limp, 6–17 mm.
St. 47. *Dol. gegenbauri.* 12 OZ(Bb), flat, limp, 6–18 mm.
St. 50. *Dol. gegenbauri.* 7 OZ(Bb), flat, limp, 6–17 mm.

All the OZ (St. 40–50) show preponderating width of M_3 and M_4, and all but one show $M_3 > M_4$.

I. d. *Equatorial Belt.* 6° N.–6° S., 20° W.–25° W. May 12–19, 1913.

St. 51–59, Fernando Noronha to Equator, and 60 (2° N.).—None.
St. 61 (2° N.). *Doliolum denticulatum.* 35 GZ (2–3 mm.), 2 PZ (3–4 mm.), 1 PZ (?) (2 mm.).
St. 62 (4° 50′ N.).—None.
St. 63 (6° 10′ N.). *Dol. denticulatum.* 8 GZ (3–4 mm.), 1 PZ (4 mm.).

I. e. *North Sub-Tropical.* May 26–June 3, 1913.

St. 64–69 (23° N.–30° N., 33° W.–35° W.).—None.
St. 70 (Azores).

Dol. gegenbauri. 17 GZ, 2–4 mm.; 3 PZ, 2–4 mm.
Many of the GZ had remnants of a peduncle, even at 4 mm. End. $2\frac{2}{5}$–$4\frac{2}{5}$; G. 3.5$\frac{1}{5}$.5.

Dol. denticulatum. 21 GZ, 3–4 mm.
Do. (?) 1 Ooz., type A_1, 2·5 mm. (cf. st. 83). Intermediate between Keferstein and Ehlers' figs. 2 and 4 (l.c. Pl. X.).
Endostyle short, *between* M_3 and M_5 ; Intestine straight, anus under M_8 ; Brain behind middle of interspace ; Otocyst just in front of M_4, otolith 0·045 mm. ; Muscles exceeding half the interspaces ; M_3 to M_5 with their interspaces=0·12–0·20–0·14—0·20–0·14 mm., i.e. eurymyonic and mesoclinal.

AREA II.—SOUTH PACIFIC.

The Plankton stations of the "Terra Nova's" Winter Cruise in 1911 were based on a centre at the Three Kings Islands, off the northernmost point of New Zealand. The area between these islands and the mainland was sampled more or less continuously during July, August and September, and the investigations were extended once in each month along three lines, one to the N.W. along the line of the submarine ridge which connects the Auckland Peninsula and the Three Kings with Norfolk Island, and two at right angles to the above, i.e. to the S.W. Although these three lines of outlying stations ran only a small fraction of the distance towards the Australian coast 1,200 miles away, from an oceanographic standpoint they were strategic lines, and I have therefore separated them from the general stock of stations concentrated in the passage, 35–40 miles wide, between the Three Kings Islands and Cape Maria van Diemen. The area of this central group (*b*) may for brevity be termed "Kings Passage," and the three special lines defined as follows :—

(*a*) The July Cross-line—a series of 9 stations (st. 71–79) which represents a general sampling of the region across the base of the "ridge." It began in the "Passage," about 10 miles E.S.E. from Great King (st. 71), rounded the Three Kings to the N.W. (st. 72–76), and from st. 77, about 8 miles W., ran away to the S.W. about 60 miles from Great King (st. 78), this furthest station being close up to the 171st Eastern Meridian (34° 39′ S., 171° 6′ E.). Station 79 on the return, was 10 miles less distant.

(*c*) "Along the Ridge," an August series of 19 stations extended along the line of the submarine ridge from Dominions Bay on the N.E. side of the mainland (st. 94), round North Cape (st. 97), about the Islands (st. 98–111), and then away to the N.W., to stations respectively 45 miles (st. 112), 80 miles (st. 113), and 110 miles (st. 114) from Great King. This, the furthest station north, rather more than halfway between Cape Maria and Norfolk Island, lay at 32° 55′ S., 170° 38′ E.

(*d*) The September Cross-line was essentially a repetition of the July line, but extended a little further at each end, 11 stations altogether. It began (st. 132–6) in Spirits Bay between North Cape and Cape Maria, ran due north to the 34th Parallel (st. 137), then past the Three Kings (st. 138), and about 20 miles to the S.S.W. (st. 139, 140), then away westwards to stations approximately 50 miles (st. 141), 80 miles (st. 142), and 110 miles W.S.W. from Great King, the last station (143) being at 34° 58′ S., 170° 12′ E.

Two Plankton stations followed series (*e*) at North Cape (st. 145, 146), and may be regarded as a repetition in September of stations 94 and 97 in August.

A year later (August-September, 1912), according to Harmer and Lillie's "List of Stations," Plankton was collected in the Bay of Islands on the N.E. coast (st. 148), but it apparently contained no Doliolids, unless a tube simply labelled "Winter Cruise ? —Surface" represents it. It contained a few *Doliolum denticulatum*, and some young oozooids of *D. mülleri*, which, apart from this, were only taken at stations 111 and 113.

Station 148 is said in the "List" mentioned to have had no "provisional station-number." It would be interesting if a connection between the two could be established, as the Bay of Islands, it may be remembered, was intimately associated with Huxley's classical investigations on *Doliolum denticulatum*, which he found at the entrance of the Bay "in considerable numbers." Unless the tube mentioned belongs to st. 148, no Doliolids of any kind were taken by the "Terra Nova" on the N.E. coast; but it should be borne in mind that all the "Terra Nova" collections in Area II were taken during the southern winter. How far that may have affected the situation, I am unable to say.

The stations follow in numerical order, which in this area is also the chronological order.

(*a*) *The July Cross-line* (st. 71–79).

No samples received from any of the 9 stations. One of these (st. 74) was a vertical haul (0–120 metres) with the Apstein net. I cannot, of course, be certain that no Doliolids were taken.

(*b*) *Kings Passage*, (i), July (st. 80–93).

St. 80–82. Three vertical hauls (0–100 metres). No results received.

St. 83. 8 miles W.N.W. of Cape Maria. July 23, 1911.

Dol. gegenbauri. 5 GZ (3–4 mm.), 1 PZ (4 mm.). End. $M2\frac{1}{4}$–$M4\frac{2}{5}$; G. 3.6.5; T reached M_3 in 1, M_2 in 3, and passed M_1 in 1.

Dol. denticulatum. 30 GZ (2–4 mm.), 5 PZ (2–3 mm.), 2 (?) mutilated.

One of the 4 smallest GZ (2 mm. T M_3) had a long peduncle, 2 others a basal stump.

Do. (?). 1 Ooz., type A_2, 1·9 mm. (cf. st. 70).

As A_1, but stenomyonic. Otolith 0·05 × 0·04 mm.

St. 84. 15 miles S.W. by W. from Cape Maria. July 24, 1911.

Dol. gegenbauri. 1 GZ (crumpled).

Dol. denticulatum. 45 GZ (2–4 mm.), 18 PZ (2–5·9 mm.).

St. 85. 24 miles W.N.W. from Cape Maria. July 24, 1911.

Dol. denticulatum. 49 GZ (2–4 mm.), 19 PZ (2–4 mm.).

The peduncles of the PZ were small, and few carried any buds.

St. 86. Close to the Islands. July 25, 1911.

Dol. mülleri (?), 1 small OZ (Bb), 3·4 mm.

Crumpled and decayed; otolith loose and brain absent. M_4 and M_5 widest and equal.

Dol. denticulatum. 20 GZ (2–4 mm.), 6 PZ (3–5 mm.).

Peduncles of PZ mostly minute, with few traces of small buds.

St. 87–89. No results received.

St. 92. 24 miles S. by W. from Great King. July 27, 1911.

Doliolina mülleri, 1 small OZ (Bb), 2·0 mm.

Enclosed in a thick viscid test; brain normal, but otolith absent; blastophore stumpy, bearing 5–6 small buds.

Dolioletta gegenbauri. 1 GZ (<3 mm.).

Doliolum denticulatum. 31 GZ (2–4·5 mm.); 8 PZ (2–3 mm.).

In all the GZ T reached M_2 and reached or even surpassed M_1 in 21. The 12 oral valves completely closed the mouth. The atrial aperture was also closed to a seeker, but the valves were invisible.

The PZ had vestigial peduncles and apparently no buds.

St. 93. 13 miles S.E. by S. from Great King. July 28, 1911.

Dol. gegenbauri. 1 GZ, about 4·5 mm., but crumpled; 3 PZ.

All the PZ are much crumpled, but about 4·5, 5·5 and 7·5 mm. long when extended. The first has a peduncle bearing small buds, the 2nd a minute peduncle without buds, the large one no peduncle at all, but a $\wedge$-shaped kink in M_7 ventrally, directed forwards, representing point of reunion of the previously interrupted muscle-ring (cf. st. 107, under *Dol. denticulatum*). This specimen (but not the others) lacks gill-slits, while retaining endostyle and gut.

Dol. denticulatum, a great swarm, analysed as follows:—

	Body-length (mm.)				Total numbers		
	3	3	4	5	Total	Not measured	Grand total
(1) Gonozooids							
T to M_2 ..	24	216	93	3	336	33	369
M_3 ..	4	41	1	3	94	12	106
M_4 ..	2	3	1	—	6	—	6
M_5 ..	—	2	1	—	3	—	3
Ovary, no testis	—	—	1	—	1	—	1
	30	262	142	6	440	45	485 (GZ)
(2) Phorozooids	1	19	21	8	49	52	101 (PZ)

The number of gill-slits was counted in a few gonozooids of different size (cf. st. 107, and *Incert. Sed.* (1), p. 55), as follows:

Length (mm.)	Gill-slits of one side		Total
	Dorsal	Ventral	
2·5	25	15	40
2·6	25	17	42
3·6	25	21	46
3·8	32	18	50
4·8 and 5·2 ..	45	32	77

In all structural relations (apart from *number* of gill-slits) the smaller specimens (<3 mm.) agreed exactly with the larger, the gill-slits beginning just in front of M_2 or abreast of it, the curve occupying the front half of the 5th interspace, and the slits ending ventrally exactly at M_3. Endostyle always exactly M_2–M_4, and intestinal relations equally constant.

One of the gonozooids (4·3 mm.) contained an ovum in its vitelline membrane free in the cloaca. It was slightly larger than the largest of the 5 or 6 eggs in the lobulate ovary.

(c) *Along the Ridge*, August 1911 (st. 94, 97 and 114).

St. 94, 97. N.E. Coast of Mainland. July 30 and August 3, 1911. No results.

St. 98, 99, 104, 105. Vertical hauls 0–80 metres. No results.

St. 100–103. 5 miles S.W. from West Island. August 4, 1–6 p.m. No results.

St. 106. 5 miles S.W. from West I. August 4, 7–8 p.m.

Dol. denticulatum. 2 GZ, 4 mm.; 2 PZ, 3 and 5 mm.

St. 107. Same as St. 106. August 4, 8 p.m.–5.30 a.m.

Dol. gegenbauri. 1 GZ, crumpled, probably 5 mm.

Do. OZ (Bb), one 7 mm. M_3 and M_4 are the widest muscles, $M_3 > M_4$. No trace of otolith.

Dol. denticulatum. 40 GZ (2–5 mm.), 13 PZ (3–5 mm.).

In excellent condition. The testis extended to M_2 in 24 (3–5 mm.), to M_3 in 9 (2–4 mm.), to M_4 in 3 (2 mm.), and to M_5 in 4 (2 mm.) In one of the largest GZ the testis was swollen up to M_4 and extended up to M_2 as a moniliform thread. In another (also 5 mm.) which had presumably discharged its last egg, the ovary was a mere speck surrounded by a large empty membranous sac, apparently an ovarian blood-sinus in the cloacal wall, as it was also visible in other specimens as an equally large jacket around the normal ovary. In all the 4 mm. GZ (19) the ovary was well developed and more or less lobulate, except one in which both ovary and testis (to M_3) were poorly developed.

In a typical 5 mm. GZ the gill-slits were counted on one side as 40 dorsal and 31 ventral = 71 (cf. st. 93).

The largest PZ (5 mm.) still possessed a slender peduncle, but the ventral limbs of the muscle-band (M7) were no longer interrupted, having reunited at its base, forming a $\wedge$-shaped kink, directed forwards (cf. st. 93, under *Dol. gegenbauri*).

Do. OZ (C), one 5·5 mm.

The muscular cuirass is incomplete over the brain, where there is a small fenestra. Otocyst 0·10 mm., enclosing OL, 0·05 × 0·04 mm.

St. 108. 10 miles S.W. from Great King. August 5, noon–4 p.m. No results.

St. 109. As 108, but through the night, 8 p.m.–8 a.m.

Dol. denticulatum. 18 GZ (3–5); 9 PZ (3–7 mm.).

In excellent condition. In a 3 mm. GZ the whole testis, though extended to M_2, was a mere filament; in three 4 mm. GZ the testis was moderately swollen up to M_3 and connected with M_2 only by a filament.

St. 110. 12 miles W.N.W. from Great King. August 6, 9 p.m.–4 a.m. None.

St. 111. Close to the Islands. August 7, 10 a.m.–1 p.m.

(1) *Doliolina mülleri.* One Ooz., type B, 1·4 mm.; 18 OZ (Bb), 1·5–7·0 mm.

These old nurses are all in a decayed condition. All are without otoliths except the smallest, in which the otolith (0·04×0·03 mm.) is loose in the pharynx! Some are without brains. One (3·7 mm.) appeared to have its brain in the 3rd instead of the 4th interspace, and was to have been treated as a meristic abnormality until it was found that the brain had simply broken adrift! Yet the muscles are measurable, and in all the banded specimens from this station, except one recorded doubtfully under (3), M_4 and M_5 are the widest muscles, and approximately equal.

(2) *Dolioletta mirabilis.* 1 GZ, 3·6 mm. (+peduncle, 2 mm.); 157 PZ, 3–6 mm. (+long peduncles).

The gonozooid had obviously broken loose very recently from a phorozooid, probably before capture, or there would have been more in the sample. It shows a testis exactly as figured by Neumann (1906, as *D. chuni*), except that the recurrent lobe extends back to the hinder end of the stomach, the left side of which it closely invests. M_6 is incomplete ventrally both in GZ and PZ.

The PZ are large, flabby, with long stalks supported by muscular bands, with very slender muscle-rings, and a remarkably loose, soft glairy test, which in these specimens is often completely peeled backwards off the body, in an inverted condition, and is either set entirely free, or, more usually, hangs from the peduncle of the phorozooid to which it adheres firmly.

These dumbbell-shaped gelatinous objects frequently become entangled by their peduncular "necks," and produce the illusion of a fragment of blastophore

carrying a series of fine buds, but only half of them are zooids; the other half are empty skins.

For supplementary remarks on structure, see p. 220.

(3) Do. (?) An old nurse (Bb), 3·0 mm., possibly belongs here.

M_3 and M_4 equal and widest; body very broad and delicate. Otolith large, 0·065×0·05 mm. (cf. st. 126).

(4) *Dol. gegenbauri* (?), 3 Ooz. type C, — 0·9, 1·2 and 1·8 mm. (C_1–C_3).

(5) *Dol. denticulatum*, 49 GZ, 3–5 mm.; 50 PZ, 1–7 mm.; 13 (?); 7 OZ (C), 4–7 mm.

The relative abundance of PZ, and their small size, are unusual and doubtless related to the presence of old nurses. The following is a survey of all the GZ and PZ that were measurable:—

Mm.	1	2	3	4	5	6	7	Total
GZ	—	3	21	18	3	—	—	45
PZ	7	12	19	9	1	—	1	49

Below 3 mm., the endostyle is not completely in front of M_4, as it is in later stages of growth. At 1 mm. the posterior cæcum distinctly projects behind it; at 2 mm. it reaches the hinder edge of M_4, but does not overstep it; at 3 mm. it only reaches the front edge of M_4 (cf. remarks on *D. nationalis*, supra, p. 223). The branchial formula in the smallest phorozooids was the same as in larger ones, viz. $2{\cdot}5\frac{1}{2}.3$.

The three largest old nurses (6–7 mm.) are beautifully expanded and barrel-like. The sphincters are contracted, with the effect of truncating the extremities, literally like the ends of a barrel. Most of the specimens show small fenestræ in the muscular cuirass at one or more of the following places—behind the brain, in front of the otocyst, and behind the stolon. In one specimen (6·8 mm.) there is a clear membranous streak between M_7 and M_8 all round. The otolith shows no regular increase in size with growth of the body, and varies from 0·035×0·03 mm., in the smallest (4·0) to 0·04×0·03 mm. in the largest (7·5) with intermediates such as 0·05×0·04 mm. at 4·8 mm., and 0·04×0·035 mm. at 5·4 mm.

St. 112. 33° 37′ S., 171° 30′ E., 45 miles N.W. from Great King. August 8. Noon–4 p.m.

Doliolina mülleri. 4 OZ (Bb), 5·7 mm.–7·8 mm.

M_3, M_4 and M_5 are nearly equally broad in these old nurses, but M_3 is never wider than the others, and in two cases is narrower. Averaged, M_4 and M_5 are the widest and M_4 is slightly $>M_5$. No otolith can be detected.

Doliolum denticulatum. 3 OZ (C), 5·6–7·5 mm. (Otoliths 0·05 mm.)

St. 113. 33° 12′ S., 171° 05′ E. 80 miles N.W. from Great King. August 9. 9 a.m.–noon.

Doliolina mülleri. 1 GZ, 2 PZ, 1·6 mm., and 3 mm.; 2 tailed larvæ, with large caudal vesicles, in elongated cysts. 4 Ooz. type B, 0·8, 1·10, and 1·55 mm.; 22 OZ (Bb) from 1·9 mm. to 5·6 mm.

The Phorozooids are in very poor condition. The smaller has a thick dirty test, the larger none (cast ?). Endostyle $M2\frac{7}{8}$–5 and M3–5 respectively. Gill-slits not countable, but numerous, 20–40 pairs, all behind M_5—*i.e.* var. *krohni*, Borg.

The old nurses are also in bad condition. Only two possess otoliths, one of 1·9 mm. (OL, 0·04×0·03 mm.), the other of 4·0 mm. (OL, 0·06×0·05 mm.). Below 2 mm. the 4 central muscles (M_3–M_6) are equally wide; above that size M_4 and M_5 predominate. A specimen of 5·4 mm. shows a rare abnormality; M_3 is completely divided into two unequal rings, so that there are 10 muscles altogether.

Dolioletta gegenbauri (?), 2 Ooz. type C, 1·5 mm. (C_4–C_5).

Dol. mirabilis (?). A small PZ, 1·0 mm. with slender, much convoluted muscles, a short spiral gut, and endostyle 2–5.

Doliolum denticulatum. 17 GZ, 1–4 mm.; 6 PZ, 2–5 mm.; 5 (?); 2 OZ (C), 3·3 and 5·0 mm.

The otolith in the smaller oozooid measures 0·04 × 0·025 mm. In the other it is obscured by wrinkles.

St. 114. 32° 33′ S., 170° 38′ E., 110 miles N.W. from Gt. King. August 10. 10 a.m.–4 p.m.

Dol. mülleri. 10 OZ (Bb), 4–8 mm.

All in poor condition and without otoliths. In the two smallest (4 mm.), M_{4-6} in one and M_{3-6} in the other are equal and widest; above that size M_4 is the widest, or shares that condition with M_5.

Dol. denticulatum. 118 GZ and 34 PZ, of sizes as below:—

Mm.	2	3	4	5	6	Total
GZ	11	45	57	4	1	118
PZ	—	5	18	10	1	34

Do. 9 OZ (C), 4·5–6·5 mm.

The otolith varies in size from 0·04 to 0·05 mm., and in shape from round to oval.

(*b*) *Kings Passage,* (ii), *August* (11 stations).

St. 116, 117. Vertical hauls (0–150 metres). August 16, 1911. No results.

St. 118, 120, 122. Surface hauls, 50-mesh net. August 17–18. No results.

St. 125. *Off N.E. Coast.* 18-mesh net. August 23. No results.

St. 126. 7–8 miles, S.E. from Gt. King. 18-mesh net. August 24. 9 a.m.–noon.

Dol. mirabilis. 1 PZ, without test.

Do. (?).

An old nurse (Bb), about 6·3 mm., thin-walled and very broad, but badly crumpled, with large otocyst (0·16 mm.) and otolith (0·06 × 0·045), possibly belongs here, but differs from that of st. 111 (3) in M_4 and M_5 being equal and widest, as in *Doliolina mülleri.*

Dol. denticulatum. 13 GZ and 12 PZ, both 3–4 mm.

St. 127–131. Off Three Kings Islands. August 25–27. No results.

(*d*) *September Cross-line.*

St. 132–136. Spirits Bay (between the two northern capes). August 29–September 2. No results.

St. 137. N. of the Capes at 34° S. September 5. No results.

St. 138. Close to the Islands, September 5. No results.

St. 139, 140. 40 miles W. of Cape Maria. September 6. No results.

St. 141. 65 miles W. of Cape Maria. September 7. No results.

St. 142. 95 miles W. of Cape Maria. September 8. 9 a.m. (7th)–9 a.m. (8th).

Dol. mirabilis (?). A tangle of gelatinous debris, apparently the cast skins of this species (cf. st. 111).

Dol. mülleri.
Dol. gegenbauri — 33 Broad-banded old nurses, mostly *mülleri* (4–7 mm.), with M_4 and M_5 subequal and widest, but all except one without otoliths, the rest *gegenbauri* (3·8–9·7 mm.) with M_3 and M_4 sub-equal and widest, mostly with otoliths.

Dol. denticulatum. 7 OZ (C), 4·5–8·0 mm. The otolith in the smallest measures 0·03 mm. (round), in the largest 0·05 × 0·045 mm.

St. 143. 120 miles W. of Cape Maria. September 9. 4 p.m. (8th)–9 a.m. (9th).

Dol. mülleri (?). 1 OZ (Bb), 1·6 mm.

Much crumpled, but M_4 and M_5 slightly wider than M_3 and M_6. Otolith 0·03 mm. in middle of interspace.

Dol. gegenbauri. 1 PZ, 5 mm.

Dol. denticulatum. 15 GZ, 2–4 mm.; 27 PZ, 2–6 mm.

Incertæ Sedis.

(1) " Winter Cruise ?—Surface." (? St. 148, see pp. 243, 244, above.)

Doliolina mülleri. 1 Ooz., type B., 1·5 mm.

Agrees exactly with Grobben's fig. 16 (1882) in proportions of muscle-bands and position of organs, except that the gut loop lies further back in the 5th interspace. In this it resembles Borgert's fig. 13 (1894, Taf. VI) of var. *krohni.* Endostyle from $M2\frac{1}{2}$ almost to M_5. Otocyst projecting from front edge of M_4; otolith oval, $0{\cdot}025 \times 0{\cdot}020$ mm.

Dol. mülleri. 2 OZ (Bb), 2·8 and 4·0 mm.

M_4 and M_5 in the smaller, and M_4 in the larger specimen, are the widest muscles. Otoliths not recognisable. Allowing for the slight differences in size, the two agree closely with Grobben's figs. 17 and 18 (l.c. supra).

Dol. denticulatum. 2 small GZ, 1–2 mm.; 1 PZ, 3 mm.; 2 (?), 1–2 mm.

The smaller GZ (1·05 mm.) shows endostyle 2–4; gill-slits beginning dorsally at M_2 and ending ventrally close behind M_3; and testis with very short *stolo perforans*, not exceeding M_6. No sign of a peduncle. There are 18 pairs of gill-slits, 13 dorsal and 5 ventral (cf. st. 93).

In the larger one the testis reaches $M4\frac{1}{2}$.

(2) From " Terra Nova " Plankton samples.

Picked out and mounted by Miss Gladys Webb, Zool. Dept., University College, London.

Dol. mülleri. 1 OZ (Bb), 3·75 mm.

Muscles slightly wider than interspaces, M_4 the widest (0·40 mm.). Otolith under front edge of M_4, nearly round, 0·038 mm. Brain 0·11 mm. long $\times$ 0·13 mm. wide.

Agrees closely with Grobben's fig. 18 (l.c.) which represents an old nurse of similar size, except that the muscles here are slightly narrower and the brain is bigger (Grobben's scale of magnification, applied to his figure, yields 0·50 mm. for M_4, and 0·07 mm. for the brain).

AREA III.—SOUTHERN OCEAN.

St. 178. 67° 23′ S., 177° 59′ W. Vertical haul, 0–500 metres. 24-mesh net. December 15, 1910. 9 p.m.

Dol. intermedium. Var. *resistibile*, Neumann (1913).

Two old nurses of relatively gigantic size (15 mm. long $\times$ 10 mm. across), and with very slender muscle-bands, yielded by this haul, are very clearly referable to Neumann's *resistibile*, though for reasons already given (p. 213), I treat this form, not as an independent species, but as a cold-water variety of *D. intermedium.* All Neumann's characters for the nurse of *resistibile* (l.c. p. 22; also *Das Tierreich*, p. 14) recur in these specimens, but the " Terra Nova " specimens show some additional features of importance. *The brain lies immediately in front of M_5*, and is separated by the greater part of the wide interspace from M_4. It looks minute in comparison with the huge body, but is actually 0·17 mm. in diameter, and round in shape, i.e. larger than in the largest oozooid of *gegenbauri-tritonis* which is available for comparison (viz. 0·15 mm. L. $\times$ 0·16 mm. W. in a *gegenbauri* nurse of 17 mm.). But neither otocyst nor otolith is present in either of the " Terra Nova " specimens.

The first of these characters gives an additional link uniting *resistibile* with *intermedium*, if I am right in referring the first of Gegenbaur's unnamed oozooids (1856, Taf. XVI, fig. 14) to this species (see p. 212 above). The second (absence of otolith) suggests that these old nurses were already dead when captured (cf. p. 237). They are of the maximum size recorded by Neumann.

A third peculiarity shown by the " Terra Nova " specimens is the position and character of the heart and ventral stolon. The heart lies entirely within the 5th intermuscular space. Its anterior end is recognisable just behind M_5, and it is prolonged backwards to occupy rather more than three-quarters of the space. The stolon is a slender, elongated cone, the basal half of which underlies the hindmost quarter of the heart, while its narrow tip extends backwards as far as M_6, the front edge of which it actually overlaps. This position of the stolon in the hinder part of the 5th interspace is uncommon, and, so far as I am aware, is paralleled only by the case of the oozooid figured by Keferstein and Ehlers in their fig. 7 (l.c. Pl. LX), which has never been satisfactorily identified, but which may turn out to be that of *Dolioletta mirabilis*. Unfortunately, Gegenbaur's figure, which I identify with *intermedium*, does not represent the organs of the ventral side (cf. p. 212, above).

The two specimens of *resistibile* differ in two respects. In one specimen, which has been compressed along its major axis like a concertina, or a Chinese lantern, the thin, glairy and tenacious test is very loose, and already detached from both apertures, but adheres firmly to the base of the blastophore, which carries median and lateral buds. In the other, which has been compressed from side to side, the test is completely absent, and only the stump of the blastophore persists without any buds.

The oral aperture is surrounded apparently by only 10 small regular, triangular lips, which are very thin and delicate, and seem incapable of closing the orifice as the 12 valves do in other species, unless the slender sphincter contracts much more in life than in death. In both specimens both apertures gape widely. It is difficult to open out the axially compressed one; but the other which, flattened and in formalin, actually measures 11 mm. in length by 9·5 mm. in width, can easily and naturally be stretched to 15 mm. L. with a width of 10 mm. in the middle, tapering to 4 mm. at each end. Could the specimen be expanded, as well as stretched, a width of 10 mm. in the middle would become a diameter of 6·4 mm. A contraction of the terminal sphincters, so as to close the apertures, would in effect convert this rather broad barrel into a balloon. In conjunction with the extreme slenderness of the muscles, these considerations seem to suggest a placidly drifting life, rather than one of active locomotion.

VII. ABBREVIATIONS.

GZ = Gonozooid.

PZ = Phorozooid.

OZ = Oozooid, fully developed (= old nurse lacking viscera).

Ooz. = Oozooid after loss of larval tail, but still retaining its viscera.

Bb, Nb, and Cc (or C), following OZ = Broad-banded, narrow-banded, and continuously-coated (or cuirassed).

M_1–M_9 = the 9 muscle-bands of OZ. (M_1–M_8 in GZ and PZ.)

M$2\frac{1}{4}$ (etc.) = a point corresponding to $\frac{1}{4}$ of the interspace following M_2 (etc.)

E$2\frac{1}{2}$–5 (etc.) = Endostyle extending from half the interspace following M_2 up to M_5 (etc.).

OC = Otocyst.

OL = Otolith.

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PENGUIN EMBRYOS.

BY

C. W. PARSONS, M.A., F.R.S.E.

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WITH TWO PLATES AND THREE TEXT FIGURES.

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PENGUIN EMBRYOS.

BY C. W. PARSONS, M.A., F.R.S.E.

(Lecturer in Zoology in the University of Glasgow.)

WITH 3 TEXT-FIGURES AND 2 PLATES.

INTRODUCTION.

THE discovery of the Emperor penguin rookery at Cape Crozier, a collection of their eggs and the first description of the unique breeding habits of this remarkable bird, were amongst the most interesting of the fruits of the National Antarctic Expedition, 1901–1904. The report "Aves" (Wilson, 1907) gives a vivid account of the material. It will be noted that out of fifteen eggs enumerated (p. 2) only four contained embryos that were not decomposed: and of these, one embryo only was not fully incubated. It was imperative therefore to revisit the rookery early in the breeding season of the bird, if the hope of obtaining a collection of embryos to show a series of stages in its development was to be realised. Wilson fully understood the scientific importance of acquiring such a collection and also the almost insuperable difficulties in the way of its attainment. Both aspects of the problem are set out in his report (p. 31). With reference to the practical difficulties, he had himself discovered that the eggs are laid in the middle of the antarctic winter not on land, but on sea ice. The site chosen for the rookery is such that it is practically inaccessible. Its approaches are guarded by ice pressure ridges presenting the utmost difficulty in negotiation even in the full light of

summer, and in the winter darkness seemingly impassable. Nevertheless, when the opportunity presented itself—in the course of the "Terra Nova" Expedition—he did not hesitate to make the attempt. With two companions, Bowers and Cherry-Garrard, he made the five weeks' winter journey, beginning on June 27th, 1911, which has since been made famous in "The Worst Journey in the World" (Cherry-Garrard, 1922, vol. 1, pp. 230–299).

The journey was successful to the extent of obtaining three eggs containing embryos that were partly incubated. In due course these passed into the hands of Dr. Assheton, and after his death into those of the late Professor Cossar Ewart. The embryos were designated in accordance with small differences in size, Nos. 1, 2, and 3, No. 1 being the smallest. Dr. Assheton prepared sections of the head and body of embryo No. 1, and also cut and mounted a sagittal series of embryo No. 2. The head of this embryo was embedded in paraffin wax, but it was never cut into sections. Some notes and drawings of all three specimens were also left by Dr. Assheton, and these have been available in the preparation of the present report. The report itself, as regards the first part—on the Emperor penguin embryos—is based upon the sectioned material specified, and on the head of embryo No. 2.

1. Embryos of *Aptenodytes forsteri.*

The most striking external difference between the three Emperor penguin embryos is remarked on by Cossar Ewart in his appendix to "The Worst Journey in the World" (Cherry-Garrard, 1922). Feather rudiments in the form of papillæ are present only in the tail region of the youngest embryo, but in the two older specimens they spread over the body in countless numbers. The difference is seen in a related species, *Pygoscelis papua*, between embryos which compare with fowl embryos incubated for approximately ten and thirteen days respectively (Parsons, 1932, pp. 144 and 146). It is fair to conclude, therefore, that the stages represented do not indicate a considerable time interval between the two extremes, and that the morphological similarity between them, especially between embryos 2 and 3, is very close indeed. Unfortunately the preservation of the material is unsatisfactory. As Dr. Assheton remarks in his notes on embryo No. 2, "the epidermis has separated from the dermis in most places, preservation none too good, but very much better than that of embryo No. 1." The serial sections of embryo No. 1 bear out this statement fully. In them the brain is almost entirely absent and the sections, which were cut sagittally, are torn and distorted along the line of the top of the head. Only the cartilage remains in position. That of the otocyst, base of skull, and lower jaw is specially conspicuous. The beak of this embryo is well developed. It is unusually sharp except in some sections where—at the tip—fragments of the protecting cushion of epidermal tissue, which is commonly present in penguin embryos at this stage, still adhere. The function of this cushion under ordinary circumstances is interesting. It develops in correlation with the long beak, no doubt in order to minimise the risk of premature damage to the embryonic membranes. It may

therefore be regarded as a parallel development with that of neonychia which have the same function with regard to the developing claws (Agar, 1909).

The body sections were cut transversely. Here again, many are torn and the details of the histology cannot be made out, although the gross anatomy may be followed with comparative ease. The series correspond closely with sections similarly cut of a fowl embryo of approximately eleven days' incubation and call therefore for no special comment. The section illustrated (text-fig. 1) is in all essential details like the figure given in "The Development of the Chick" (Lillie, 1908, fig. 190, p. 329), for example, and it demonstrates clearly that the youngest Emperor penguin embryo had reached a stage in development far enough advanced to possess a four-chambered heart and lungs actively budding air sacs.

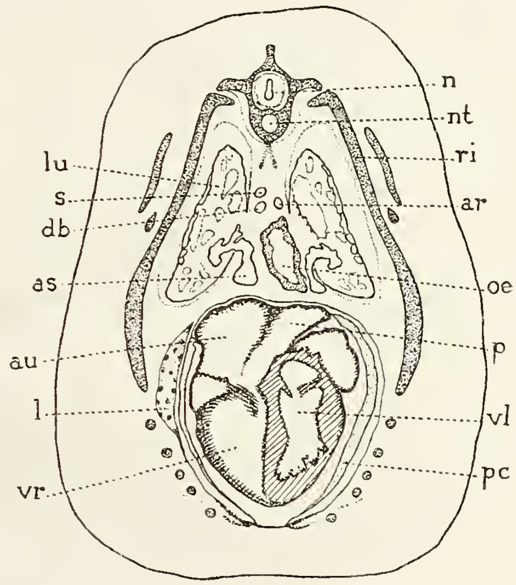

Fig. 1.—*Aptenodytes forsteri*. Embryo No. 1. Transverse section passing through the heart and lungs: *ar* aortic root, *as* air sac, *au* right auricle, *db* ductus Botalli, *l* liver, *lu* lung, *n* spinal cord, *nt* notochord, *oe* oesophagus, *p* pulmonary aorta, *pc* wall of the pericardiac cavity, *ri* rib, *s* systemic aorta, *vl* left ventricle, *vr* right ventricle.

The limbs.—Separate preparations were made of the limbs of embryo No. 1. The right wing and right leg were stained to show the cartilages and mounted whole, the left limbs were sectioned. The special interest underlying these preparations is due to an observation concerning the embryos of Emperor and Adélie penguins that were brought home by the National Antarctic Expedition, 1901–1904 (Pycraft, 1907, p. 19). In making a comparison between the two species, Pycraft noted the principal features of the adult wing in the embryo *Aptenodytes*, and showed that they were not yet present in the wing of a slightly younger embryo *Pygoscelis*. In the present instance an examination of the figures—Pl. I, figs 4 and 5—reveals that adult features are certainly lacking in the distal cartilages of the wing of embryo No. 1. Thus, the pollex has not yet fused with the metacarpal of digit 2, and between the metacarpals on one side and the radiale and cuneiform on the other, the semilunar cartilage of the distal carpal 2 is still perfectly distinct. The shape of the humerus, however, is already defined in cartilage as that typical of the adult penguin. As pointed out by Lowe (1933, fig. 12*b*, p. 515), its termination is triangular and in marked contrast with the rounded form of this part of the bone in the majority of birds. The radius, ulna and cuneiform are also completely spheniscine.

With regard to the foot, the cylindrical metatarsals are characteristically free, a feature which is generally agreed to be representative of a primitive condition.

Embryos 2 and 3.—The similarity between these two specimens has already been

stressed. They do not differ from one another probably by more than a day of incubation, and their morphological differences are superficial and trifling. In size embryo No. 3, as measured by Dr. Assheton, is only 0·5 mm. greater in length than embryo No. 2. There are also minor differences with regard to the distribution of the feather papillæ. Embryo No. 2 is without papillæ on the breast, abdomen and on the pre-axial surface of the wing, whereas embryo No. 3 is thoroughly covered with them. It is noteworthy that there are no papillæ as yet distal to the tarsal joint in either specimen, and it is obvious that the superficial differences between them are so small that it is justifiable to treat the two embryos as one for the purposes of comment.

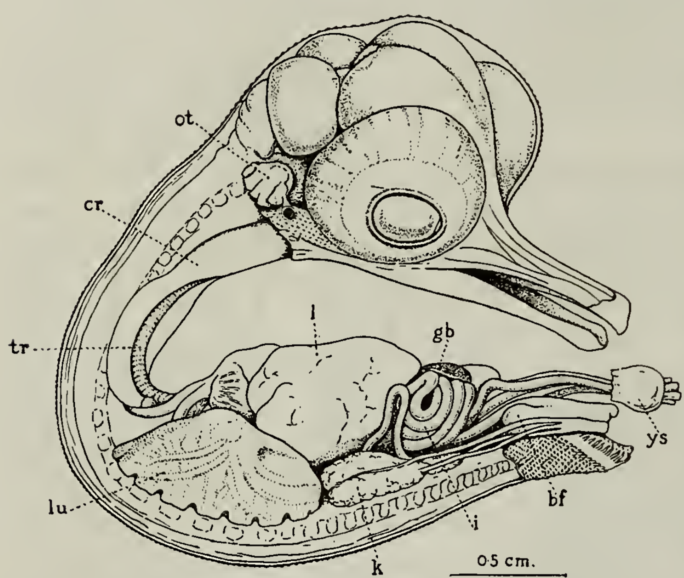

Fig. 2.—*Pygoscelis adeliæ.* Embryo with feather papillæ, equivalent to a fowl of about thirteen days' incubation. Superficial dissection of the right side: *bf* bursa Fabricii, *cr* crop, *gb* gall bladder, *i* intestine, *k* opisthonephros, *l* liver, *lu* lung, *ot* otocyst, *tr* trachea, *ys* yolk sac.

With reference to the feather papillæ, the sections—particularly those taken sagittally through the tail region of embryo No. 2 (Pl. I, fig. 8)—show them in various stages of development up to the formation of feather filaments. The papillæ consist of simple thickenings of the dermis with a thin epidermis overlaying them similar in type to those described in Gentoo penguin embryos (Parsons, 1932, p. 151), and there is no reason to suppose that their subsequent history is in any way different. If this is so the first filaments develop into down feathers which are replaced in the nestling by a second generation of similar feathers.

The drawing of the whole embryo (Pl. I, fig. 3) is composite. The head was taken out of the embedding wax and the body reconstructed from the series of sections of which fig. 8, Pl. I, represents one approximately in the sagittal plane. Both were carefully drawn and compared with photographic prints made from some old negatives of the embryo. In comparison with other penguin embryos at the same stage of development—an Adélie embryo for example—the most striking feature of the Emperor embryo is not its size, but the high dome of the head. A dissection of the head was undertaken to obtain an accurate knowledge of the contour of the brain, therefore, although it was known that the brain could not be anything but exceptionally brittle; and, in order to harden the brain as much as possible, the whole head was soaked in formalin for some days before the dissection was commenced. The resulting figures (Pl. I, figs. 1 and 2) show that there are no exceptional features: the relative proportions of the parts of the brain are the same as in Adélie embryos of the corresponding stage.

The space between the two optic lobes is, however, very wide, and is filled with a mass of loose tissue surrounding the pineal body. This accumulation of tissue provides the extensive support for the dome-like surface and is largely responsible for the characteristic shape of the head.

With regard to the thoracic and abdominal viscera, the sagittal section of embryo 2 (Pl. I, fig. 8) marks out the relative positions of the organs, and a search through the whole series shows that in this respect also the Emperor penguin embryos are not different in any important particular from embryos of other species of penguin at the same stage.

Text-fig. 2 illustrates a dissection of an Adélie embryo at about the same stage of development as the Emperor embryos Nos. 2 and 3. Besides showing the general disposition of the organs, this figure illustrates a point which is very often overlooked. It plainly shows the relatively great length of the neck. In their customary standing position adult penguins conceal its presence, but when occupied in preening themselves they may be seen bending the head downwards towards one of the feet and extending the neck to do so. In this way they are able to perform the feat of scratching the top of the head commented upon in his observations of the habits of captive King penguins (*Aptenodytes patagonica*) by Cossar Ewart (Cossar Ewart and Mackenzie, 1917, p. 124).

2. Embryos of *Pygoscelis adéliæ*.

The following observations are based upon thirteen Adélie penguin embryos collected by the expedition and representative of various stages in the development. The youngest specimens correspond roughly to fowl embryos of five and a half days' incubation, and the oldest to a fowl of approximately seventeen days' incubation. The general resemblance between the former and the fowl at the same stage is, of course, close: thus, the eyes are prominent and are pigmented, there are no eyelids, the choroid fissure is open and the predominating feature of the head is the enlarged mid-brain. They already show some features, however, that are characteristic of penguin embryos. The fore limb is directed at right angles to the hind limb, the hand is narrow and the limbs are approximately of equal length. The tail also is narrow and is well marked off from the trunk. While these specific features are important, they do not obscure the fundamental likeness between the early stages in the development of the penguin on the one hand and of the fowl on the other. For this reason in describing the penguin embryos it is best to apply as far as possible the established scheme of stages in the fowl as figured in the "Normentafel" (Keibel and Abraham, 1900).

1. Stage 29 N.T. (*i.e.*, Normentafel). Number of specimens 2: equivalent to a fowl embryo about five and a half days' incubation. Both these embryos were cut into sections—one series sagittal and the other transverse—head and body separately.

Dr. Assheton's notes on these preparations contain the following comments:—"Head.—No exceptional features except the mandible, relative length and bold curvature of which are very characteristic of penguins. Neck.—Without visceral clefts except

the hyomandibular, part of which remains as the external auditory meatus. Body.—Very bent, head and tail almost in contact. Heart.—Not yet fully formed, all the chambers distinct but the auricles still in communication with one another. Blood leaving the heart passes into one of two completely separate channels divided off the truncus arteriosus. The larger ventral vessel passes forwards, bifurcates round the alimentary canal and reunites to form the dorsal aorta. The smaller dorsal vessel is continued forwards as the carotid root. Lungs.—Connected with bronchi, posterior air sacs developing. Liver.—Well formed. Kidney.—(1) Pronephros—remains, consisting of a pair of glomeruli without funnels, persist at the extreme anterior end of the cœlome. (2) Mesonephros—well developed, no unusual features. (3) Metanephros—indicated by a condensation of cells along the inner border of a pair of diverticula of the mesonephric duct. These diverticula are the beginnings of the metanephric ducts. Gonads.—A pair of gonads recognisable. Müllerian ducts project far back into the body cavity and consist of plates of thickened peritoneum." The above comments as they stand give an accurate description of the salient features of the two embryos in question. In some particulars, however, the nomenclature used differs from that generally adopted in this report. The mesonephros, for example, does not become functionally distinct from the metanephros until much later in the embryonic period, and the term opisthonephros is therefore used to describe the developing excretory organ in accordance with the definition laid down by Graham Kerr (1919, p. 221), and the mesonephric duct is equivalent to the Wolffian duct.

It is of interest to record further that the gonads are in the form of genital folds, as the embryos are old enough to have passed the stage at which the genital rudiments first appear as ridges.

2. Stage 31 N.T. Number of specimens 1, equivalent to a fowl embryo of about eight days' incubation.

This embryo has the general characteristics of an eight-day fowl, but the short beak, nostrils and well developed tongue are features in which it resembles a later stage. A drawing was made of the specimen straightened out to show the dorsal surface (text-fig. 3 *a*), and it was then dissected and figured in side view (Pl. II, fig. 1). Its anatomy is sufficiently displayed by this means and comment is unnecessary.

3. Stage 32 N.T. Number of specimens 1, possibly a day older than stage 31.

The embryo was decapitated and the head cut into transverse sections. It shows growth of the cerebral hemispheres with the result that the mid-brain no longer projects prominently above the general surface. The eyes are slightly advanced and eyelids begin to make their appearance. The beak is 3·5 mm. long, the limbs both measure 7 mm. over-all. The uropygial gland is becoming conspicuous. In all other features the anatomy resembles that of the preceding stage so closely as to be practically identical with it.

4. Stage 34 N.T. Number of specimens 2, equivalent to a fowl embryo of about ten days' incubation.

The most noteworthy feature of these embryos is the appearance of the first feather rudiments as papillæ. In one specimen the papillæ are not very numerous and are well defined only in the tail region. In the other specimen they are much more widely distributed, being found on the surface of the head and neck and on the back and upper parts of the legs. In neither case are there any papillæ on the wings. These appear at a very slightly later stage, as described by Anthony and Gain (1913) in an investigation of the pterylosis of penguin embryos. The two specimens differ very slightly in respect of the length of beak, the smaller specimen has a beak measuring 8 mm., and the larger one measuring 9 mm. in length.

5. The seven remaining embryos in the collection are too far advanced in development to compare with the Normentafel. With only one exception they are all fledged in feather filaments developed from the feather papillæ, and they are embryos of considerable size. The exception is provided by the embryo figured in text-fig. 2, in which there is only one row of strongly developed filaments fringing the base of the tail. This specimen is comparable with a fowl embryo of approximately thirteen days' incubation and it bridges an otherwise serious gap between the stage 34 embryos and the older ones. The latter are equivalent in development to fowl embryos of between fifteen and seventeen days' incubation. The figure of the oldest (Pl. II, fig. 2) illustrates the anatomy of all and, in addition, it shows two features of special interest. In the first place it is noteworthy that many of the feather filaments are so long that they curl at the tips. It seems probable that this may lead to weakening of the filament sheaths in preparation for their future disruption and release of the complete barbs of the down feather. Secondly, the skin of the feet is marked with papillæ resembling feather papillæ. It is known, however, that they are in fact the precursors of the horny "scales" of the feet, and it has been shown elsewhere (Cossar Ewart, 1922) that such papillæ never do develop into feathers. This is remarkable because the close morphological relationship between feathers and scales seems to be perfectly well established on other evidence. Feather papillæ and scale papillæ must still be regarded, then, as being distinct from one another from the beginning, and corroboration of this opinion is provided by the sequence of the events in development. In contrast with the feather papillæ, the scale papillæ are late in making their first appearance. This would not be so if the feathers developed in the course of evolution from scales of the same kind as those which are conspicuous on the legs of adult penguins, and the explanation of the anomaly probably is that the horny scales protecting the feet of penguins and of other birds are epidermal structures of a secondary nature that are fundamentally different from reptilian scales which are the true ancestors of feathers.

CONCLUDING REMARKS.

Taking a broad view of the facts as they have been adduced, both from a consideration of the unique group of three Emperor penguin embryos and of the series of Adélie embryos, it must be stated that neither has greatly added to our knowledge of penguin embryology. At the time when the collections were made the material brought back by more recent expeditions was not, of course, at hand, and the embryos on which the work of the present report is based had the advantage of priority. This advantage was lost owing to the death of two investigators into whose hands the material had been given, and in the meantime other collections were made which enabled the foundations of our knowledge of the subject to be laid. In the light of what was already known of the development of two species of *Pygoscelis* (*Pygoscelis papua* and *Pygoscelis antarctica*), it was most interesting to have the opportunity of examining embryos of the third species, *Pygoscelis adéliæ*. As might have been expected, however, there are

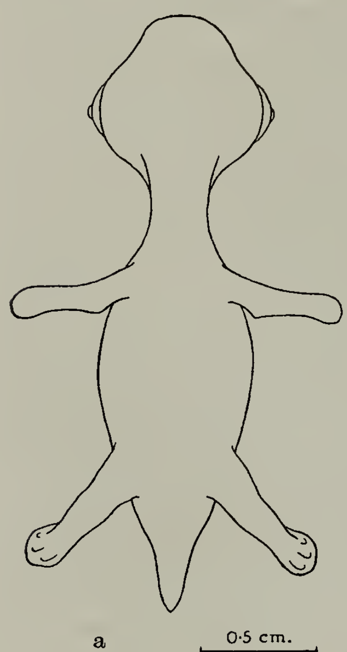

FIG. 3.—*a*, Dorsal view of an Adélie penguin embryo, Stage 31—comparable with a fowl of approximately eight days' incubation. The embryo drawn straightened out with a view particularly to showing the proportions of the tail; *b*, Dorsal view of the tail region of an Adélie penguin embryo showing the first feather filaments, Stage 34—comparable with a fowl of approximately ten days' incubation; *c*, Dorsal view of the tail of an Adélie penguin embryo fledged in feather filaments—comparable with a fowl of approximately seventeen days' incubation; *d*, Dorsal view of the tail region of a fowl—fifteen days' incubation.

NOTE.—In *c* and *d* filaments, other than those fringing the tail, have been pulled out, leaving open sockets on the surface of the skin; in *b* the mid-dorsal pit = uropygial gland; in *c* and *d* mid-dorsal prominence with feather filaments = uropygial gland.

no considerable differences between the embryos of the three species at corresponding stages in development. The Adélie embryos were distinctive because they have longer beaks in proportion than the other species, and another point of difference is in the earlier development of feather filaments on the head. The history of the development of Adélie embryos sheds no new light upon the problem of penguin ancestry, however, and unfortunately nothing decisive could be expected from the collection of three Emperor embryos so close to one another in development as those that Dr. Wilson

and his comrades obtained at such cost. A small point regarding this question of ancestry of penguins may not unsuitably be made here without raising all the arguments of previous papers on a controversial subject. The tail of the developing fowl is always a very conspicuous object in early embryos. It is conspicuous, too, in the embryo penguin, and if a comparison is made between early embryos of the two species there does not seem to be much difference between them as regards slenderness. In later embryos it is otherwise. Text-fig. 3 is designed to show that the fowl evolves its tail very differently from the penguin. In the latter it seems that the more primitive slender condition is retained in development longer than in the fowl, and this persistence of a primitive character is suggestive.

ACKNOWLEDGMENTS.

I wish to acknowledge my indebtedness to Professor Graham Kerr and Dr. Percy R. Lowe for assistance and advice in the preparation of this report, and to the authorities of the British Museum for the loan of the material. I also wish to record my deep sense of obligation to Miss C. Brown Kelly, by whom all the illustrations were prepared.

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PLATE I.

Scale: All the figures = $\times 1\frac{1}{2}$, except fig. 8 = $\times 2$.

FIG. 1.—*Aptenodytes forsteri.*		Embryo No. 2.	Dissection of brain, dorsal view: *pi* pineal body.
,, 2.	,, ,,	,, ,,	Dissection of head, side view: *is* interorbital septum, *q* quadrate.
,, 3.	,, ,,	,, ,,	Entire embryo (equivalent to a fowl of approximately thirteen days' incubation).
,, 4.	,, ,,	Embryo No. 1.	Right wing preparation: *cu* cuneiform, *mc* III, metacarpal III, *rd* radiale, I pollex.
,, 5.	,, ,,	,, ,,	Right foot viewed from the inner side, preparation: *fb* fibulare, *ha* hallux, *mt* IV, metatarsal IV.
,, 6.	,, ,,	Embryo No. 3.	The tail (drawing after Assheton).
,, 7.	,, ,,	,, ,,	Left foot, view from the outer side (drawing after Assheton).
,, 8.	,, ,,	Embryo No. 2.	Sagittal section: *bf* bursa Fabricii, *cr* crop, *gb* gall bladder, *i* intestine, *k* opisthonephros, *l* liver, *lu* lung, *p* pulmonary aorta, *pc* wall of pericardiac cavity, *s* systemic aorta, *se* sternum, *st* stomach, *tr* trachea, *ug* opening of uropygial (or preen) gland, *vom* omphalomesenteric vein, *ys* yolk sac.

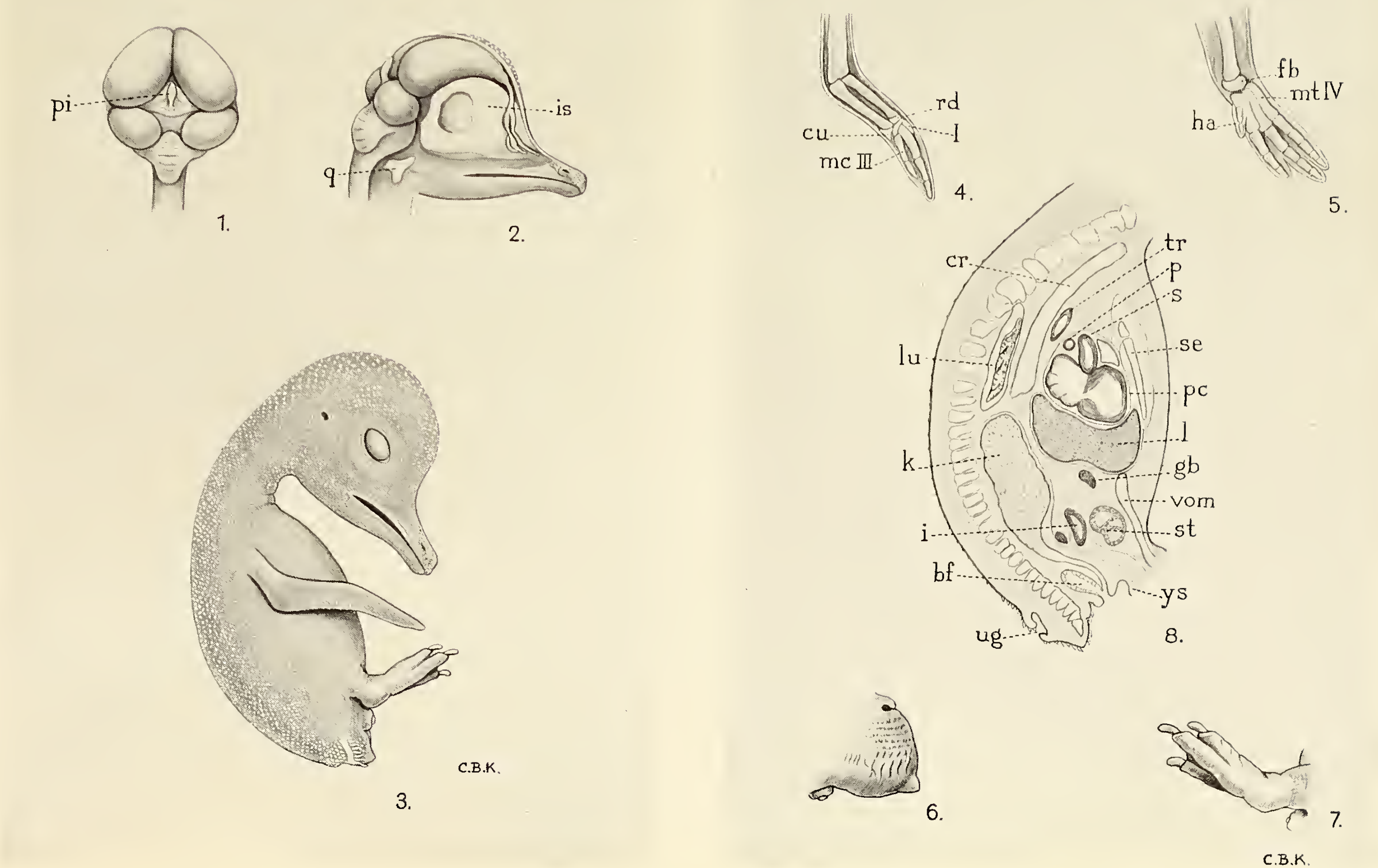
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PLATE II.

Fig. 1.—*Pygoscelis adeliæ.* Embryo N.T. 32, equivalent to a fowl of approximately eight days' incubation. Dissection of the right side, liver and right lung removed.

hp hypophysis, *if* infundibulum, *k* opisthonephros, *m* Müllerian duct, *r* rectum, *ra* right allantoic artery, *st* stomach, *ty* thyroid, *v* ventricle of heart, *y* yolk stalk.

II—X. Cranial nerves.

„ 2.—*Pygoscelis adeliæ.* Embryo fledged, equivalent to a fowl of approximately seventeen days' incubation. Dissection of the right side, right lobe of the liver, right lung and right kidney removed.

ar aortic root, *aom* omphalomesenteric artery, *au* right auricle, *bf* bursa Fabricii, *ca* carotid artery, *ce* cerebellum, *cla* cœliac artery, *cra* crural artery, *db* ductus Botalli, *gd* genital duct, *go* gonad, *hm* hemisphere, *la* left allantoic artery, *l* liver, *me* medulla oblongata, *o* optic lobe, *pa* pulmonary artery, *pi* pineal body, *ra* right allantoic artery, *sa* subclavian artery, *sp* spleen, *u* ureter, *vom* omphalomesenteric vein.

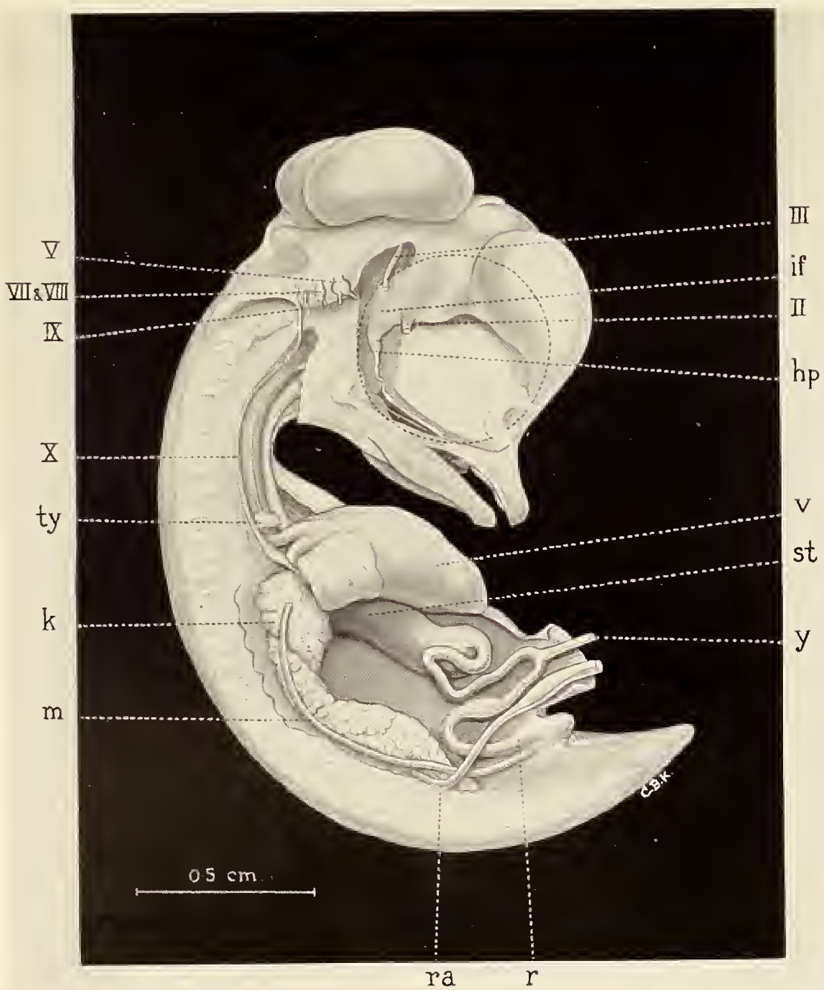
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Fig. 1.

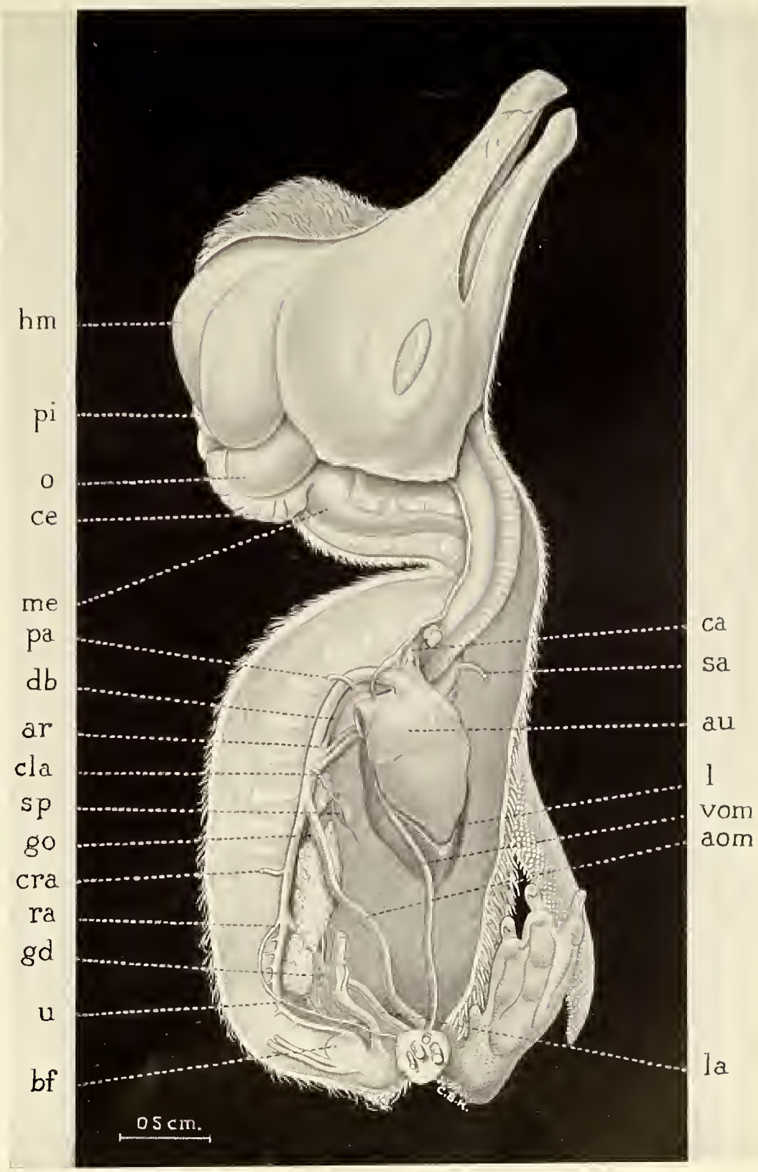
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Fig. 2.

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BRITISH ANTARCTIC ("TERRA NOVA") EXPEDITION, 1910.

NATURAL HISTORY REPORT.

ZOOLOGY. VOL. IV, No. 8. Pp. 263–282.

REPORT ON THE TUNICATA.

PART II.—COPELATA.

BY

WALTER GARSTANG, M.A., D.Sc.

[illegible]

AND

ELIZABETH GEORGESON, B.Sc., Ph.D.

WITH FIVE TEXT-FIGURES.

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REPORT ON THE TUNICATA.

PART II.—COPELATA.

BY WALTER GARSTANG, M.A., D.Sc.
(Emeritus Professor in the University of Leeds),
AND
ELIZABETH GEORGESON, B.Sc., Ph.D.

WITH 5 TEXT-FIGURES.

INTRODUCTION AND SUMMARY.

This report on the Copelata supplements my report on the Doliolids in a very special manner, and bears more closely on the biology of Antarctic waters. While the Doliolids are essentially warm-water creatures, incapable, it would seem, of prolonged existence in the neighbourhood of ice, their relatives the Appendicularians—their direct descendants, as I have tried to show elsewhere—contribute an important and highly specialised element to the pelagic fauna of both poles (Lohmann, 1905). The German South Polar Expedition of 1901–3 made a thorough investigation of the Appendicularians in the Indo-African sector of the Antarctic, and the recent publication of their report (Lohmann and Bückmann, 1926) has enabled comparisons to be made with the results of the British Expedition in the New Zealand sector ten years later. These results are of considerable interest, and help materially to round off the story as well as to define further problems.

The collections of Copelata by the "Terra Nova" include some 2,000 specimens from 34 stations. The identification of these small creatures (many of them unavoidably mutilated in various ways) requires the making of innumerable dissections and preparations, and the elucidation of their life-histories involves careful measurements on an extensive scale. I have to thank one of my former students, Miss Elizabeth Georgeson, Ph.D., for nearly two years' invaluable help in this task. She worked over the whole of the material and identified the greater number of the species present. I have since re-examined the whole material, and the present report has been prepared independently, but Dr. Georgeson's name should be associated in the authorship.

W. GARSTANG.

SUMMARY OF RESULTS.

1. The Appendicularians collected by the "Terra Nova" are all Oikopleurids, and were derived from three separate groups of stations: (1) Atlantic, (2) South Pacific, north-west of New Zealand, and (3) the Antarctic (161° E.–166° W., 64°–72° S.). Though stations were also distributed between 36° and 64° in the New Zealand sector, no specimens were received from that area.

2. Of nearly 2,000 specimens from 34 stations not less than 1,900 belong to two species: *Oikopleura longicauda*, Vogt, which dominates the collections in the warm waters of the Atlantic and South Pacific, and was found at every station represented, and *O. valdiviæ*, Lohmann, which similarly predominates in the Antarctic collections, and was found at every station in that area.

3. For *O. longicauda* it is shown that the maximum and average size attained in the South Pacific are higher than in the tropical Atlantic, and that the difference is associated with an earlier ripening of the ovary in the latter area.

4. For *O. valdiviæ* it is shown that a very small proportion attain maturity of the ovary before the final stage of growth (3–4 mm. body-length), while the records suggest a definite short breeding season late in the Antarctic summer. This is correlated with the evidence of seasonal variations in number published by the German South Polar Expedition. The sequence of stages in development of the gonads is given, and certain peculiarities of the house-rudiments are described.

5. The other species found in the collections are *Oikopleura cophocerca, rufescens,* and *dioica*, and a few individuals of the less familiar genera *Stegosoma*, *Folia*, and *Pelagopleura*, the first of these from Atlantic and Pacific stations, the two last from the Antarctic.

6. A new species is proposed for the specimens of *Stegosoma* and similar specimens already described from Japan, which differ from typical representatives of *S. magnum* from the Atlantic and Indian Oceans (*S. conogaster*, n. sp.).

7. The single specimen of *Folia* is much larger than any previously described, and in consequence of structural peculiarities is assigned to a new species (*F. gigas*, n. sp.).

8. The three specimens of *Pelagopleura* are referred to Lohmann's species *P. magna*, and yield additional information on various points of structure. The presence of food-remains in each individual corroborates Lohmann's view that the species is a normal inhabitant of Antarctic deep water, to which it appears to be confined.

9. A mutilated specimen which combines large oral glands with two continuous rows of amphichordal cells is described but cannot be referred to a known genus.

10. Attention is drawn to the failure of the "Terra Nova" in the New Zealand sector to obtain specimens of *Oikopleura gaussica* and *Pelagopleura australis*, which were taken repeatedly by the German Expeditions in the Indo-African sector of the Antarctic.

COLLECTING STATIONS.

The stations at which Appendicularians were collected fall into three groups, represented on Plates I, II and III of Harmer and Lillie's "List of Collecting Stations" (Brit. Antarctic "Terra Nova" Exped., Zool. vol. II, No. 1, 1914), as follows:

I. ATLANTIC.

1. Equatorial (Plate I). May, 1913.
    Stat. 52.—5° S. 27° 15′ W. Depth 2 metres. May 12, 1913.
    ,, 57.—4° 30′ S. 27° 16′ W. Surface. May 13.
2. S. Atlantic (Plate III). April 1913.
    Stat. 310.—36° 57′ S. 51° 21′ W. Surface. April 21.

II. SOUTH PACIFIC, NEW ZEALAND WATERS (Plate II).

July 17 to August 24, 1911.
    Stat. 76.—8 miles W. from Summit, Gt. King. Surface. July 7.
    ,, 85.—24 miles W.N.W. from C. Maria van Diemen. 2 metres. July 18.
    ,, 88.—10 miles S. from Summit, Gt. King. 1 metre. July 22.
    ,, 102.—5 miles S.W. from West I., Three Kings. Surface. Aug. 4.
    ,, 107.—5 miles S.W. from West I., Three Kings. Surface. Aug. 4.
    ,, 111.—Off Three Kings Is. Surface. Aug. 7.
    ,, 114.—32° 55′ S., 170° 38′ E. Surface. Aug. 10.
    ,, 115.—34° 32′ S., 172° 20′ E. Surface. Aug. 16.
    ,, 126.—34° 13′ S., 172° 15′ E. Surface. Aug. 24.

III. SOUTHERN OCEAN, NEW ZEALAND SECTOR, S. of 36° S. (Plate III).

No specimens were received from any of the open sea stations north of 64° S.

1. Dec. 1910. [Working a passage south through exceptionally thick pack-ice: "terribly heavy floes" (Scott's Journal).]
    Stat. 178.—68° 23′ S., 177° 59′ W. 0–500 metres. 24-mesh. Dec. 15.
    ,, 180.—68° 26′ S., 179° 08′ W. 100 metres. 24-mesh. Dec. 22.
2. March 1911 (the only station E. of 180°).
    Stat. 195.—65° 14′ S., 161° 24′ E. 2 metres. Mar. 6.
3. Dec. 1912 and Jan. 1913.
    Stat. 264.—64° 33′ S., 166° 30′ W. 20 metres. Dec. 26.
    ,, 267.—66° 30′ S., 166° 8′ W. Surface. Dec. 27.
    ,, 269.—68° 37′ S., 166° 14′ W. Surface. Young fish trawl. Dec. 28.

3. Dec. 1912 and Jan. 1913—*continued.*

Stat. 270.—69° 51′ S., 166° 17′ W. 0–600 metres. 24-mesh. Dec. 29.
,, 271.—71° 23′ S., 166° 3′ W. Surface. Dec. 31, 1912.
,, 272.—71° 35′ S., 166° 01′ W. 80 metres. Jan. 1, 1913.
,, 274.—71° 29′ S., 166° 0′ W. 80 metres. Jan. 3.
,, 275.—71° 29′ S., 166° 0′ W. 160 metres. Jan. 3.
,, 276.—71° 41′ S., 166° 47′ W. 0–1750 metres. Jan. 5.
,, 281.—71° 41′ S., 166° 47′ W. 80 metres. Jan. 6.
,, 282.—71° 41′ S., 166° 47′ W. 0–1000 metres. Jan. 7.
,, 283.—71° 39′ S., 166° 47′ W. 80 metres. Jan. 7.
,, 284.—71° 49′ S., 167° 32′ W. 80 metres. Jan. 8.
,, 285.—71° 49′ S., 167° 32′ W. 0–600 metres. Jan. 8.
,, 286.—71° 44′ S., 167° 57′ W. 10 metres. Jan. 9.
,, 287.—71° 44′ S., 167° 57′ W. 80 metres. Jan. 9.
,, 288.—71° 59′ S., 168° 43′ W. 60 metres. Jan. 11.
,, 289.—72° S., 168° 17′ W. 24 metres. Jan. 12.
,, 290.—72° S., 168° 17′ W. 60 metres. Jan. 12.

DISTRIBUTION.

OIKOPLEURIDÆ

1. *Oikopleura longicauda*, Vogt (= *O. spissa*, Fol).

535 specimens (66 tailless). In every sample forwarded from the Atlantic and South Pacific areas, viz.:

Atlantic: st. 310 (37° S.), 52 and 57 (5° S.), all in April and May 1913.

South Pacific (32°–36° S.): st. 76, 85, 88, 102, 107, 111, 114, 115, 126, all in July and August 1911.

2. *O. valdiviæ*, Lohmann.

1,172 specimens (547 tailless). In every sample forwarded from the Southern Ocean, south of 36° S. (except st. 310 above). The stations are all in the New Zealand sector between 161° E. and 166° W., and between 64° and 72° S., viz.:

Dec. 1910.—st. 178 and 180.

March 1911.—st. 195 (the only station E. of 180°).

Dec. 26, 1912.—Jan. 12, 1913.—st. 264, 267, 269, 270, 271, 272, 274, 275, 276, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290.

3. *O. cophocerca*, Gegenbaur (*non* Fol).

Several specimens at st. 52 (Atlantic).

4. *O. rufescens*, Fol.

Several at st. 52 (Atlantic), one at st. 111 (South Pacific), and several of a distinct variety at one of the Antarctic stations the original station number of which is illegible. The tube contained many *O. valdiviæ*, and was of the "E" series (*i.e.*, 264–290).

5. *O. dioica*, Fol.

Common at st. 52 (Atlantic); two specimens only at st. 107 (South Pacific).

6. *Folia gigas*, n. sp.

One specimen at st. 274 at 80 metres (Antarctic).

7. *Stegosoma conogaster*, n. sp.

Two solitary specimens at st. 310 (South Atlantic) and 76 (South Pacific), both at the surface.

8. *Pelagopleura magna*, Lohmann, 1926.

Two at st. 275 (160 metres), one at st. 276 (0–1750 metres), both Antarctic, 71° S.

9. *Gen. et sp. indet.*

One mutilated specimen with the preceding at st. 275 (see notes, p. 281).

NOTES ON THE SPECIES.

1. *Oikopleura longicauda* (Vogt, 1854).—This small species is usually at once detected in a mixed collection by its characteristic dorsal veil, which suggested Langerhans' expressive term '*velifera*' (1880). Its dominance in the "Terra Nova's" Atlantic and South Pacific samples, and its absence from the Antarctic stations, is but a further confirmation of its world-wide value as a warm-water indicator. Lohmann writes "*Die Deutsche Süd-polar Expedition fand sie in warmen Wasser des Atlantischen und Indischen Oceans überall, sie fehlte aber vollständig im Antarctischen Meere*" (1926, p. 146). It was "*weitaus die häufigste Art*" in the "Siboga's" collections from the Indian Archipelago (Ihle, 1908, p. 112). It is "the most common species" off the Pacific coast of Japan, especially "in summer when the south wind prevails and the Black Current sweeps nearer the land than in other seasons" (Aida, 1907, p. 24).

The varying state of the oikothelium (= oikoplastic epithelium) of Appendicularians renders these little creatures difficult to measure with precision, but the following table sums up the range of size, as indicated by the body-length, in the measurable specimens taken by the "Terra Nova" (Miss Georgeson's measurements).

Length (mm.)	Atlantic Stations (April and May)	South Pacific (July–August)
0·3	1	1
0·4	2	18
0·5	11	35
0·6	17	33
0·7	7	46
0·8	1	19
0·9	—	11
1·0	—	9
Totals . .	39	172
Average size .	0·55 mm.	0·65 mm.

So far as the figures go, they indicate that the species attains a larger maximum and average size in the South Pacific than in the tropical Atlantic. Although the Atlantic numbers are very small, each of the three stations here combined yields the same modal size (0·6 mm.), so that the result is probably not without significance.

It is associated with an earlier maturation of the ovary, the species, as usual in *Oikopleura*, being protandric. In the following table the size at which the ovary was recognisable is tabulated for the Atlantic stations and for a combination of the two most productive stations in the South Pacific, viz., stations 107 and 115.

	Atlantic (April–May)			South Pacific (July–Aug.)		
Length (mm.)	Number measured	Ovary present	Per cent.	Number measured	Ovary present	Per cent.
0·3–0·5	14	9	66	46	11	24
0·6	17	10	59	25	10	40
0·7	7	6	86	39	29	74
0·8	1	1	100	12	8	67
0·9–1·0	—	—	—	17	16	94
Totals .	39	26		172	74	

None of our specimens attained the maximum size of 1·20 mm. recorded by several other workers (Fol, Langerhans, Aida); but the measurements given above corroborate Lohmann's remarks as to the variability of this species in regard to the size at sexual maturity. He mentions the occurrence of very small individuals with ripe gonads (0·3–0·45 mm.), in contrast with the usual size which he gives as from 0·55–0·8 mm. (1926, p. 146). This variation, while general, is now seen to have also a regional character, the majority of Atlantic specimens (mainly tropical) becoming fully mature at a distinctly smaller size (about 0·5 mm.) than those in New Zealand waters (0·7 mm.). The difference is doubtless a function of the external temperature, as in the corresponding case of Doliolids (Part 1 of this Report, 1933, pp. 206–7).

As regards the growth of the tail, Aida gives 4·06 mm. as the length of the tail in his largest specimen, 1·20 mm. in body-length, a ratio of 3·38 : 1. Fol, from living material, assigns a tail-length of 4·2 to a *longicauda* of the same size, a ratio of 3·5 : 1. Both these ratios are small in comparison with the few measurements I have made of smaller specimens:

Body-length	Tail-length	Ratio
0·45	2·4	1 : 5·3
0·6	3·5	1 : 5·8
0·75	4·3	1 : 5·7

It is possible that at first the tail grows more rapidly in length than in breadth, and in later stages more in breadth than in length (cf. *O. valdiviæ*, p. 272).

2. *O. valdiviæ*, Lohmann (1905) (Text-fig. 1a–k, 2a–b).—As *longicauda* dominates the warmer seas, so *valdiviæ* was the characteristic Appendicularian of the ice-zone traversed by the "Terra Nova." But a problem of some importance is raised by the fact that the German South Polar Expedition, working along the ice-edge in the adjacent quadrant, about 90° E., found not one, but two dominant species, of which *O. gaussica* was even more abundant than *O. valdiviæ*. At the "Gauss's" winter station

in 66° 2′ S., 89° 38′ E., Appendicularians were collected through an entire year (Feb. 1902–Feb. 1903), and 83 per cent. of the Oikopleurids consisted of *O. gaussica*, against only 14 per cent. of *O. valdiviæ*. Subsequently, when the ice broke up, and the ship drifted for two months with it (Feb. 9–April 8, 1903), these proportions were reversed (38 per cent. *gaussica* as against 59 per cent. *valdiviæ*) ; but the fact remains that both species were present throughout the year in this quadrant, and neither Dr. Georgeson nor I have been able to find a single indubitable *gaussica* in the " Terra Nova " collections. Stragglers of other species from distant tropical or subtropical latitudes drifted into the " Terra Nova's " nets, but *gaussica*, which we may assume was still present in the neighbouring quadrant, was completely absent from surface and deep-water hauls alike, both in the summer of 1910–11 and two years later in 1912–13.

The problem is somewhat comparable with that of *O. vanhöffeni* and *labradoriensis* in the North Polar Sea, the latter species having a wider temperature range, while the former is purely Arctic. In the present case, however, both species are strictly Antarctic, and the evidence of any difference in their thermal relations has hitherto been very slight. The highest temperature of the sea at the " Gauss's " winter station was − 1·5°, except in January, when it rose to + 0·7°. This was one of the only three months when both species did not occur together, but it was *valdiviæ*, not *gaussica*, that was missing. During the two months' drift of the ship, when *valdiviæ* exceeded *gaussica* in numbers, the temperature never exceeded − 1·4°. Similarly in the open sea (" Westwindtrift "), clear of the ice-pack, both species fell off greatly in numbers, and only stragglers were obtained north of the Antarctic Circle, *valdiviæ*, it is true, a little farther north and more frequently than *gaussica*—the " Valdivia " having in fact first taken the former species north of Kerguelen (52° 47′ S.) at a surface temperature of + 2°. On the other hand the " Gauss " took *gaussica* on one occasion as far north as 58° 26′ S. at a surface temperature of + 1·8°.

These facts certainly indicate that, while both species are essentially ice-lovers, *valdiviæ* can endure a slight elevation of temperature more easily than *gaussica*. The entrance to the Ross Sea between 170° E. and 170° W., where the " Terra Nova's " *valdiviæ* stations were clustered, notoriously tends to be freed of ice sooner and longer than any other part of the Antarctic circle. Indeed it was this knowledge which determined the vessel's attempted line through the pack on her outward voyage. It indicates presumably a stronger influence from tropical inflows. However slight the difference between the two species in their relations to temperature, this feature of the Ross passage may be assumed to have favoured *valdiviæ*, as compared with *gaussica*, in collections concentrated in those waters ; but the complete absence of *gaussica* in both years appears to indicate that here at any rate there must be a continual inflow from the Pacific, intersecting the Southern Ocean with a constant barrier of relatively warm salt water that never gives *gaussica* a chance to establish itself. Further observations on the distribution of the two species and their relations to physical factors are obviously desirable.

Lohmann gives the maximum body-length of *O. valdiviæ* as 3·50 mm. This size was exceeded by an appreciable number of the "Terra Nova" individuals, the largest of which measured 4·1 mm. The following table gives an indication of size-distribution

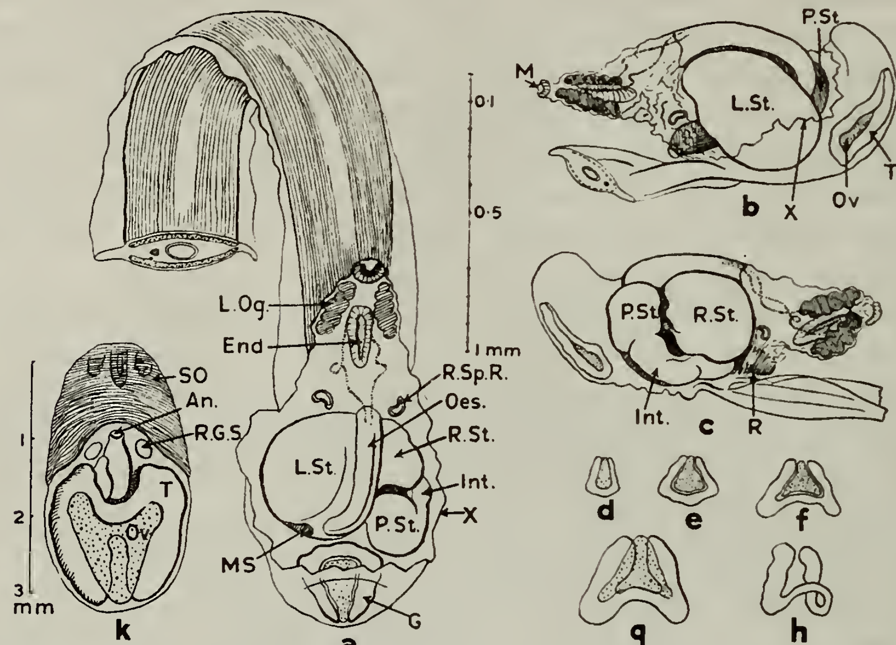

FIG. 1.—*Oikopleura valdiviæ*, Lohm.

a, dorsal, *b*, left, and *c*, right aspects of an immature individual (1·3 mm. body-length) from which the dorsal oikothelium has been removed.

d–k, successive stages in the growth of the gonads. *h* shows the testis only; *k* shows both glands *in situ*, the ovary still as a thin triangular disk (ventral view).

in the whole collection, those collected in 1910 showing the same modal (2 mm.) and submodal (1 mm.) lengths as the larger samples of 1912. In addition the numbers are recorded of specimens with developed ovaries (Miss Georgeson's dissections and measurements):

Body-length (mm.)	Number measured	Number with ripening ovaries	Per cent.
<1	87	—	0·0
1	263	7	2·6
2	428	22	5·1
3	231	17	7·4
4	6	6	100·0
Totals . .	1015	52	

These figures contrast strikingly with those for the preceding species, and suggest that in *O. valdiviæ* the attainment of female maturity is a slow process with a marked seasonal periodicity. It is obvious that at the period when these samples were collected

(*i.e.*, the Antarctic midsummer) the great bulk of the population was still immature, while the sudden increase in ovarian maturity that accompanies the last increment of size suggests that a further period of growth would be necessary before the bulk of the population would be ready for breeding. This means that the breeding season for *O. valdiviæ* must fall in the latter half of the Antarctic summer, and not in the spring as is usual with marine animals in temperate latitudes.

These inferences accord well with the elaborate quantitative investigations of the "Gauss" at its winter station in 1902–3, which revealed a sudden increase and maximum density of small pelagic organisms (Tintinnids, Radiolaria, Fritillariid Appendicularians) in March, but of Oikopleurids (*i.e.*, *gaussica* and *valdiviæ*) not until April, *i.e.*, three months later than the period of the "Terra Nova's" collections. A slight initial increase beginning in January may well be correlated with the reproduction of the more precocious individuals of our table (cf. Lohmann u. Bückmann, l.c. pp. 216, 217, fig. 54).

This late flourishing of Appendicularians in polar waters appears to be equally marked in the Arctic region, though the evidence is more fragmentary. Lohmann and Bückmann (l.c. p. 216) cite figures for the west coast of Greenland from countings by Vanhöffen, from which it appears that a climactic period is shown there by *Fritillaria* in October and by *Oikopleura* in November, the rise from the low winter level beginning in each case 1–2 months earlier. In the Spitzbergen region the climax is probably earlier. The "Nautilus" collected a number of Appendicularians there between Aug. 30 and Sept. 4, 1931, which came into our hands for examination. All belonged to the species *O. vanhöffeni*, which is said to attain a maximum body-length of 7 mm. These specimens, which ranged from 0·5 to 2·5 mm. in length, were completely immature, neither testis nor ovary being recognisable. They would accordingly seem to be the offspring of a breeding season a month or two earlier, *i.e.*, July or July–August, though the data are too isolated for a safe conclusion. In any case, so far as Appendicularians are concerned, it seems clear that the first half of the short Arctic or Antarctic summer is required for completing the growth to maturity of a scanty winter population, and that reproduction is mainly by a short breeding season that falls in one of the later summer months, typically September or October in the Arctic region, February or March in the Antarctic.

Lohmann has briefly characterised the development of the gonads from a flat disk, "with central separation of the triangular ovarian part" (1905, p. 360). The earliest noticeable rudiment, at 1·0–1·5 mm. body-length, has the form of a slender isosceles triangle, with truncated apex directed upwards and backwards, which is divided into three nearly equal parts, testes externally and ovary in the middle (text-fig. 1a–d). The lateral testes, however, are connected basally by a transverse connecting piece ("isthmus"), so that the testis as a whole forms a slender frame round the central triangular ovary, and is interrupted only at the truncated apex, where the tip of the ovary separates the tips of the two testicular limbs.

At about 2 mm. body-length the rudiment has broadened basally into an equilateral triangle, still showing the same general arrangement (text-fig. 1e).

At about 2·5 (2·0–3·0) mm. the apical angle has become obtuse, and the testicular base of the triangle is produced into a pair of short wings which apply themselves to the sides of the intestinal knot (text-fig. 1f). The connecting isthmus tends to curve outwards below and behind the base of the ovary (text-fig. 1h). The whole testicular rim thickens, at first uniformly, then with increasing effect on its postero-lateral wings. All this time the ovary remains as a thin semi-transparent triangular plate within the testicular frame.

At about 3·0 mm. the lateral parts of the testis broaden and thicken underneath the ovarian triangle, while the isthmus remains slender (text-fig. 1g). The ovary is still a thin triangular plate, slightly produced at its two outer corners or nearly crescentic, and covering the median gap between the lateral lobes of the testis, which it partly overlaps on either side.

At 3·5 mm. the postero-lateral wings of the testis have extended forwards so as to embrace the sides of the gut-knot almost completely (text-fig. 1h). The ovary begins to thicken in the middle and penetrate inwards between the two lobes of the testis, but preserves its primitive relations externally.

At 4·0 mm. the ovary is itself a solid thick, more or less lobulate organ wedged in between the testicular lobes, and more or less completely enveloped by them, so that it can only be clearly seen by dissection.

When massively developed (3·0–4·0 mm.) the apex of the gonadial mass protrudes dorsally to a slight extent behind the oikothelial plate. It is morphologically interesting to note that in quite small specimens (1–2 mm.), provided they are well-preserved and uncontracted, this large genital hump, with its short, blunt, apical horn, can be seen to be preformed, while the gonadial rudiment is a mere triangular shield lodged within its otherwise empty blastocœlic cavity (text-fig. 1b, c). In most cases, however, the thin epithelium clothing the genital hump has collapsed inwards except where it overlies the rudimentary gonadial plate, so that the apex of this shield ventrally and that of the stiff oikothelium dorsally project behind the body like a pair of opposed valves, giving a characteristic bilabiate appearance to most of the preserved specimens.

The relations of body-length to tail-length are approximately as follows, but subject to variation :

Tail-length (mm.) .	5	7	9	11	14	16	17
Body-length (mm.) .	1·2	1·5	2·0	2·5	3·0	3·5	4·0

When the tail has reached a length of 14–15 mm. it appears to undergo a relatively greater increase in breadth than in length, though I have made no measurements to confirm this point. The subchordal cells are clear and distinctive in well-preserved specimens, usually 7 or 8 (6–10) in number.

The para-pharyngeal glands (" oral-glands ") are very large and oblong in shape in most of our specimens, whether large or small. They are usually as long as the endostyle, but begin in front of it and terminate about the same distance from its hinder apex (text-fig. 1a).

Detached rudiments of " houses " (unexpanded of course) were found in many of the samples. They are usually coated inside and out with particles of planktonic débris which obscure their structure, and two points, one on either side of the centro-dorsal area, are peculiarly adhesive, so that many of the houses exhibit a pair of irregular fibrous tufts at these points. As Lohmann has described and figured a pair of gelatinous " beaker-shaped " papillæ near the same points in the house-rudiment of *O. albicans* (1896, Taf. XII, figs. 8, 9), it was desirable to investigate these adhesive points, which seemed in many cases to be directly produced into two or three fine filaments. The houses are readily cleaned by shaking them violently in a tube of hot water, and are then very interesting objects, showing the structural elements of the food-trap and the crossed fibres of the filtering windows very beautifully.

The house-rudiment (text-fig. 2a, b) as a whole appears to be made of much firmer material than that of *O. albicans*. It presents a very definite shape, resembling that of a low Prussian helmet, and is stiffened regularly by special gelatinous bands. Referring for descriptive purposes to Lohmann and Bückmann's nomenclature of the oikothelium (l.c. figs. 4, 9, 13), the most conspicuous feature is the pair of elevated oval gelatinous patches in front which cover the fibres and pipes of the *food-trap* (c′, c‴). Below these the suboral region protrudes in front of the morphological mouth (= the ultimate exhalant aperture) like a visor in front of a mediæval helmet, and is supported by two half-hoops of gelatinous material, one above the other, of which the upper (morphologically anterior) is much the stronger, and is yellowish in colour. These bands appear to be the product of the horizontal rows of cells forming the front part of L. and B.'s " *Kehlgegend*," and may be appropriately distinguished as the *upper* and *lower suboral bands*. The *filtering windows*, corresponding to Eisen's oikoplasts (d), lie near the lower concave edge of the middle of the helmet on each side; and from their hinder margin there runs backward on each side a strong gelatinous bar, the pair of which meet and fuse with one another in the median or sagittal plane, together forming a single *postero-lateral half-hoop between the two windows*. This seems to be the product laterally of " Ihle's Field " (l), and dorsally of the middle row of large cells of area (i) in front of the " posterior rosette " (n).

Behind this postero-lateral half-hoop in the median line a transversely oval gelatinous papilla is often recognisable, forming the centre of a weaker crescent of festooned elements wedged in between the stronger parallel bands. Behind this again, and forming the main part of the posterior " neb " of the helmet, is a bilobed terminal plate of thick jelly, with tapering lateral wings, apparently divided in the middle line by a longitudinal streak, which is really a deep-lying fibre. On either side of this streak is a curious double scroll, which forms a kind of *fleur-de-lys* pattern, plainly formed by the " posterior

rosette" (n). The parallel rows of elongated marginal cells (m) give rise to the thin edge of the posterior neb of the helmet.

Between Fol's *oval* (c) and Eisen's oikoplasts (d) there runs an *oblique row* (g) of cells on each side of the oikothelium, to which another pair of *oblique lateral* bands of jelly correspond in the house. These are united by a kind of *gelatinous buckle* in the mid-dorsal line, the product apparently of the front row of large cells of area (i) immediately behind the "anterior rosette" (h). This itself gives rise to a sheet of clear jelly

FIG. 2.—*Oikopleura valdiviæ*, Lohm.

a, dorsal, and *b*, left side views of two house-rudiments, detached from the oikothelium and cleaned to show the principal gelatinous and membranous elements.

ALP.	. Antero-lateral Papilla.
AP .	. Adhesive Patch (in *a* covered by a quadrangular scale, in *b* produced into fibrils).
ASB.	. Anterior Suboral Bar (yellowish).
CP .	. Central Papilla, divided internally by a median thread or septum (from "Anterior Rosette").
DB .	. Dorsal Buckle (clear stiff jelly), connecting the two Oblique Bars.
FC .	. Festooned Crescent.
F.O .	. Fol's Oval, containing the series of filter-pipes.
FW .	. Filtering Windows, with crossed fibrils.
L.Hk	. Lohmann's "*Haütungskörper*," the principal group of them.
M .	. Mouth (future exhalant aperture and valve). (In *b* its position is indicated, but it is not actually visible from the side.)
OB .	. Oblique Bar.
PLB	. Postero-lateral Bar (from "Ihle's Field").
PMP	. Postero-median Papilla.
PO .	. Præ-oval.
PS .	. Posterior Scroll (from "Posterior Rosette"). The median partition is a deep-lying fibre.
PSB	. Posterior Suboral Bar.

at the apex of the helmet, the centre of which is marked by a characteristically bisected oval area. The pair of *adhesive patches* mentioned earlier lies on either side of this centre of the anterior rosette, from which they are separated only by a narrow tract of clear jelly on either side. They seem accordingly to be the product of the large cell or cells which form the apex of "Martini's Field" (f). The patches themselves are sometimes produced into 1–3 slender adhesive fibrils, sometimes mere amorphous deposits on the outer edge of a curious valve-like scale, sometimes recognisable only by their adhesiveness.

If reference now be made to L. and B.'s figures of the oikothelium of *O. albicans* (l.c.

figs. 12, 13) and to Lohmann's earlier figures of the house-rudiment (1896, pl. xii, figs. 5, 7, 8), it will be seen that the gelatinous "beaker-shaped" papillæ are probably, as these authors suggest (p. 82), the product of the giant-cells named "Leuckart's Field" (Fig. 13, *o*), a group which is supposed to be absent from the oikothelium of all other species.

As we know nothing of the function of these curious papillæ, or of the adhesive patches of *valdiviæ*, it would be unprofitable to go minutely into the question of their possible correspondence, but it may be pointed out that the "mantle" of small cells, which isolates Martini's field in *gaussica* and *valdiviæ*, is absent in *vanhöffeni* and *albicans*, so that a general homology between the specialised Leuckartian cells of *albicans* and the apical cells of Martini's field in other species is not impossible. *O. cophocerca*, which in other respects is an almost direct connecting link between *albicans* and *valdiviæ*, shows an intermediate condition also in this area of the oikothelium (L. and B., l.c., fig. 14). In it there is a peculiarly enlarged cell dorsolaterally which certainly corresponds to the apical Martini-cell in *gaussica* and *valdiviæ*, as the incipient "mantle" above it shows: but this mantle is so rudimentary and Martini's field in general so diffuse that the large cell may equally well be claimed through *vanhoffeni* as a homologue of one or more of the Leuckartian cells of *albicans*.

A comparative study of house-rudiments in connection with the pattern of the oikothelium is clearly indicated as the next desirable step in Appendicularian morphology.

3. *O. cophocerca*, Gegenbaur (1855, not Fol, 1872).—This is a purely warm-water form. We have occasionally suspected its occurrence in Antarctic samples, but the specimens have mostly resolved themselves into young *valdiviæ* which closely approach it in various respects.

4. *O. rufescens*, Fol (1872).—This is another warm-water species and its occurrence in typical form at stations 52 and 111 calls for no comment. But the few Antarctic specimens doubtfully referred to it have peculiarities which with fuller material might justify the definition of a new species intermediate between *O. rufescens* and *dioica*. The left stomach is ovate in outline as in *rufescens*, but horizontally placed and unusually shallow, so that the full extent of the rectum is visible below it. The œsophagus enters it postero-dorsally as in *dioica*. The right stomach is even shallower than the left, and provided with a distinct ventral cæcum as in *rufescens* which overhangs the outer wall of the rectum. The latter runs horizontally, projects slightly in front of the stomach, and terminates by a short anal papilla on its ventral side, not, as usual, by its extremity. Ihle also refers to specimens from the Indian Archipelago with a horizontal rectum (1908, p. 14). Unfortunately the tails of our specimens are missing, so that the evidence of their subchordal cells is unobtainable. It will be seen that the reference of these specimens to *rufescens* is at most an approximation, and cannot be regarded as extending the range of typical members of the species.

5. *O. dioica*, Fol (1872).—This commonest species of many coastal waters is capable

of enduring a wide range of temperature and salinity. In the Atlantic it is recorded from the South Equatorial stream to the North Sea, but avoids the cold Labrador and Benguela currents. It seems to be relatively scarce in the Indian Ocean (Zanzibar-Kanal, Lohmann), but occurs on both sides of the Pacific. The Atlantic specimens at station 52, though small, were typical, and showed the two subchordal cells without fail. The two specimens from New Zealand waters (station 107) were unfortunately tailless.

6. *Folia gigas*, n. sp. (text-fig. 3a–e).—It is probably significant that our single specimen of this remarkable form was taken in a net towed (nominally, at any rate) at a depth of 80 metres. Lohmann is emphatic that *Folia gracilis* is essentially a deep-sea species of the tropical regions, and it would be difficult to account on any other theory for the occurrence of as many as thirteen individuals in a single haul of a closing-net worked from 390 to 190 metres in the Guinea current. The "Gauss" took only a single specimen in the Antarctic, and that by a vertical haul of 0–2000 metres during the ship's drift in the ice.

In several respects the "Terra Nova" *Folia* from station 274 is unique. It is appreciably larger than any of the specimens hitherto recorded (not more than twenty altogether). The delicate pharynx is crushed backwards upon the rectum, and so twisted that the oral region with endostyle and oral glands protrudes sideways from this region —practically at right angles. The *maximum* length of previous specimens is given by Lohmann and Bückmann as 0·484 mm. This new specimen from anus to the hinder end of the stomach alone measures 1·4 mm. If this region be assumed to bear the same proportion to the total body-length as in Lohmann's first figure (1896, Taf. XIX, fig. 1), the body-length of the "Terra Nova" specimen cannot have been less than 3·25 mm.

Oikothelium, body-wall, gonads and tail are completely absent from this specimen, except a small piece of ovary which encrusts the posterior apex of the stomach. The complete genital glands must have filled the blastocœlic space behind the gut as in Lohmann's fig. 2 (l.c.), since they are known to develop from a tripartite postero-ventral discoidal rudiment, as in *O. valdiviæ*. It follows that the empty blastocœlic cavity with its parietal genital shield, often figured to represent the typical form of *Folia*, *Stegosoma*, etc., is not a special adaptation for flotation, as several times suggested, but an example of the preformation in youth of an arrangement required in maturity, exactly as in *O. valdiviæ* and its relatives (p. 272).

The general conformation of the gut closely corresponds with Lohmann's account, but the larger size of this individual permits a more exact tracing of the morphological limits, which show that the whole gut is much more normally constituted than appears from previous figures. The stomach is not a simple pyriform sac, but an asymmetrical ovoid bag set obliquely across the plane of the œsophagus and compounded of a posterior left and an anterior right lobe imperfectly straightened out. The latter gives rise in front to a true "post-stomach" separated by a groove ventrally, from which the short

intestine arises on the right side to open into the rectum obliquely on its right side ventrally. In fact, if we take as a starting point the gut of a *fusiformis* with its anteriorly produced rectum, all that is necessary to produce the gut of a *Folia* is, as it were, to pull the rectum still further forward, thus dragging the intestine and post-stomach to the front of the right lobe of the stomach, and straightening the relations of the right to the left lobe of the stomach at the same time.

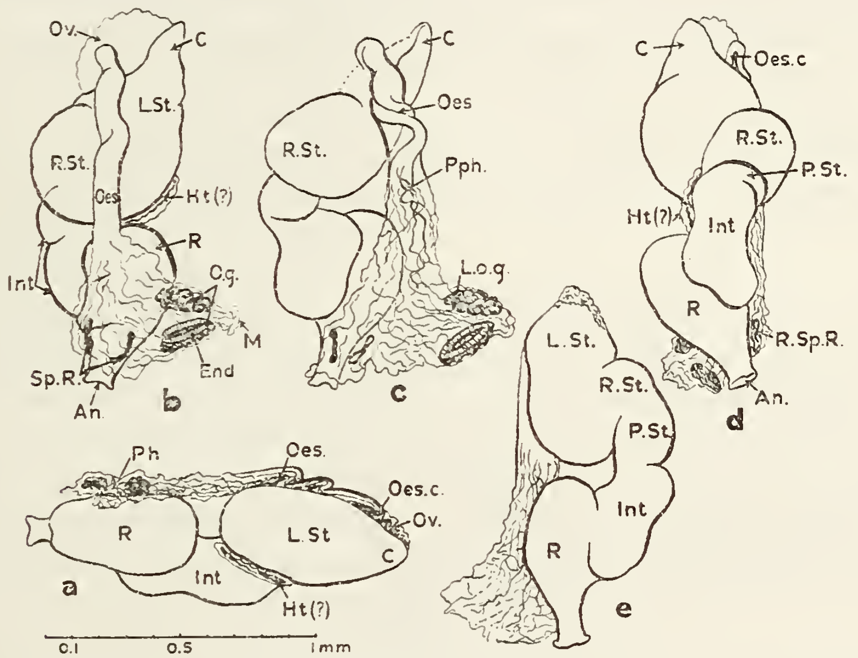

FIG. 3.—*Folia gigas*, n. sp.—Five successive views of the single specimen, as seen by rotating it in glycerine under a binocular dissecting microscope.

a, left side, showing crumpled œsophagus, with its cardiac end imbedded in a fragment of ovary, and the pointed post-cardial gastric cæcum.

b, dorsal view, showing the same features, the existence of a left lobe of the stomach, and the pair of large oral glands on one of which the endostyle lies.

c, dorso-dextral view, showing the pair of peripharyngeal bands entering the œsophagus separately, and the small spiracular rings.

d, ventro-dextral view, to show the cardiac loop of the œsophagus and the distinct nature of the right lobe of the stomach.

e, ventro-sinistral view, emphasizing the last point and showing the differentiation of a distinct "post-stomach" between right stomach and intestine.

Note.—After figures b and e were drawn, the ovarian tissue was partly cleared away with needles to expose the cardia. This was definitely located (a, d), but the underlying tissue of the left gastric wall and cæcum was injured in the process (c).

Further differences from previous descriptions are to be seen in the oral glands and peripharyngeal bands. The former, instead of being *klein* or *verhältnissmässig klein*, are large, oblong, and conspicuous; although the endostyle, which seems injured, is too obscure to enable us to compare the relative size of the two organs. The peripharyngeal bands, which are represented as meeting beneath the brain in Lohmann's fig. 1, or half-way towards the œsophagus in his fig. 2, must in this specimen have been

exceedingly oblique, since they can be traced as independent bands to the very mouth of the œsophagus over the front edge of the stomach.

Some of these differences may be due to imperfect observation, others to varying rates of growth, but the constant character of the oral glands at all stages of growth in *O. valdiviæ* suggests that there may be specific differences in this respect. If there is only one species the fact that Lohmann's specimen with massively developed testes (fig. 2) was not more than one third the size of the present one would indicate a difference in the rate of maturation in a presumably deep-sea species hardly consistent with the relative uniformity of the conditions. We therefore create a new species for the " Terra Nova " individual, distinguishing *Folia gigas* by its large oblong oral glands, its large size (3 mm. with mature ovary), and the obliquity of its peripharyngeal bands which are independent structures from endostyle to œsophagus. As the " Gauss's " specimen of *F. gracilis* had probably drifted into the Antarctic from the Indian tropics, so the original home of the " Terra Nova's " *F. gigas* was probably the tropical Pacific.

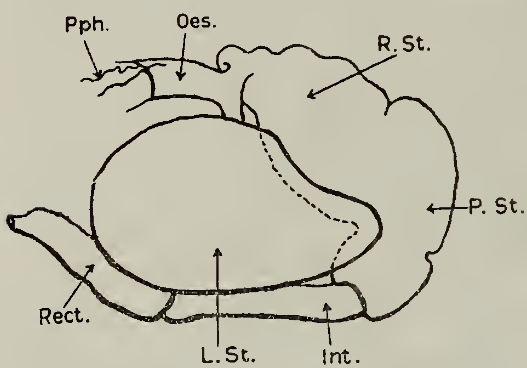

FIG. 4.—*Stegosoma conogaster*, n. sp. Left side of intestinal loop. Slightly diagrammatic above, to show the slender intergastric connection, which in both specimens is hidden behind the upper edge of the left stomach owing to contraction.

7. *Stegosoma conogaster*, n. sp. (text-fig. 4). (*Stegosoma magnum*, Aida, 1907, p. 21, not *Oikopleura* [*Stegosoma*] *magna* Langerhans (1880).—The two specimens of *Stegosoma* found by the " Terra Nova " were fished in surface nets, the first during the winter cruise of 1911 off the Three Kings Islands, north-west of New Zealand (station 76, July 7th), the second in the South Atlantic on the homeward voyage in 1913 (station 310, April 21st). These specimens retain their tails, though in poor condition, but the delicate pharyngeal region is severely crumpled in each case. In the form of the alimentary canal both specimens agree closely with Aida's account of Japanese specimens (1907), the pouch-like left lobe of the stomach having the form of a bilaterally compressed oval, broad anteriorly and tapering conically behind to a bluntly pointed posterior apex. The narrow pseudo-cardiac stalk, which connects the left with the right lobe and receives the œsophagus, opens into the pouch in the middle of its dorsal edge. This form of stomach differs appreciably from the somewhat quadrangular wallet-shape figured by Chun (1888), and Lohmann for North Atlantic and Mediterranean individuals.* The tapering posterior cone is sufficiently well-marked to deserve the title of a cæcum, whereas in North Atlantic forms the gastric stalk enters the pouch behind the middle (Chun, l.c., fig. 1 ; Lohmann, 1896, fig. 2), and the posterior wall of the pouch is rounded much more obtusely than in the Japanese and our specimens. In this respect the Japanese and " Terra Nova " specimens occupy an intermediate position between typical *magnum*

* See postscript, page 281.

and the remarkable form obtained by the "Valdivia" in the Indian Ocean, to which Lohmann has given separate generic rank as *Chunopleura microgaster* (Lohmann, 1914). In it the gastric stalk opens into the front end of the pouch and the blunt cæcum of our specimens is further produced and attenuated.

On these grounds we have decided to create a new species for the Japanese type of *Stegosoma* and to refer our specimens to that species. The chief distinctive point is the production of the posterior wall of the gastric pouch into a bluntly conical cæcum. The facts indeed suggest that *S. conogaster* may prove to be the typical Pacific species, of which the two "Terra Nova" individuals were outliers, the first, from New Zealand waters (station 76, July 1911), needing no special comment, the second (station 310, April 1913) having accidentally rounded the Horn and been caught in the north-going Falkland current, like the single individual of *Pelagopleura australis* which the second German Antarctic Expedition fished in the South Brazil stream on Aug. 23, 1911 (Lohmann u. Bückmann, l.c., p. 156).

Both the "Terra Nova" specimens are without any trace of gonads, the larger of the two probably from loss, the smaller (which retains its epithelium) from immaturity. Only the visceral region of the body admits of measurement in either case. The length of this region in the first and larger specimen (station 76), from front of œsophagus (the rectum being broken) to hindmost point of the post-stomach, is 1·3 mm., yielding an estimated total body-length of 2·9 mm.; tail, 6 mm. That of the smaller specimen (station 310), from anus to the same point behind, is 0·65 mm., yielding a total estimated body-length of 1·2 mm.; tail, 3 mm. Aida's largest specimen from Japanese waters had a tail of 13 mm., with an estimated body-length of 3·8 mm.

The *Stegosomas* are now recognised as essentially epiplanktonic and tropical, German expeditions having taken as many as 250 *S. magnum* in one haul in the Sargasso Sea ("National," 1889), and 213 in the Indian Ocean, south of Réunion ("Gauss," 1903). The single specimen taken by the "Gauss" during its drift in the ice-pack at 64° 6′ S. is regarded by Lohmann as a "tropical guest," carried to the Antarctic by underflow from the Indian Ocean.

8. *Pelagopleura magna*, Lohmann (1926) (text-fig. 5 a, b).—The three specimens we refer to this species were obtained at two adjacent stations in the Antarctic (275 and 276) within two days of one another (Jan. 3rd and Jan. 5th, 1913). They all possess the enormously elongated spiracular rings by which Lohmann and Bückmann distinguish this species (1926, p. 153). The first two at station 275 are large-bodied, but difficult to measure owing to contortion of the pharyngeal region. One (A), with a tail of 16 mm., is almost or quite 4·0 mm. long, the other (B), which is tailless, actually measures 3·8 mm. over-all, but it is more mutilated, has lost its epithelium behind, and must have been larger than A when alive. The former (A) contains streaks of degenerate tissue in its expanded posterior cavity, which suggest that it had discharged its genital products before capture, the epithelium being ruptured along the mid-ventral line. Its tail, though in poor condition, exhibits "amphichordal" cells as small dark granules

dispersed irregularly and thinly along each side, with a tendency to form separate groups posteriorly. B exhibits a long endostyle with many pairs of large outer glandular cells, and an internal paired series of smaller cells. It is almost as long as the rectum (actually about 0·8 mm.) and nearly as wide. The stomach and other parts of the gut in both specimens are much wrinkled. The rectum in both contains fæces.

The third specimen (C), taken at station 276, is much more perfect, but smaller (body-length, 2·0 mm.; tail, 6·0 mm.). Mouth, ciliated funnel, peripharyngeal bands, and spiracular rings are much less crumpled, and can be traced out almost completely; the brain is obscure, but the spherical organ on the left side (text-figs. 5a and 5b) may well be the otocyst or otolith; the whole digestive tract is clear at a glance. The stomach is fully expanded as a perfectly smooth spherical sac slightly compressed from side to side. The gut is completely empty except the rectum, which, as in A and B, is filled by a loose pellet of fæces almost ready for discharge. All the parts into which the gut of an ordinary *Oikopleura* is differentiated can be identified, as in *Folia*, though here the right and left lobes of the stomach are completely unified, and the "pulling forward" of the right limb of the intestinal knot has been carried out more completely. Gonads are present in rudimentary form as a flat dumb-bell-shaped disk across the postero-ventral side of the stomach, as figured by Lohmann (L. and B., l.c. Abb. 43). Unfortunately the tail of this specimen has completely lost its epithelial fins, so that the blastocœle gapes widely, exposing the notochord, and all amphichordal cells have been washed away.

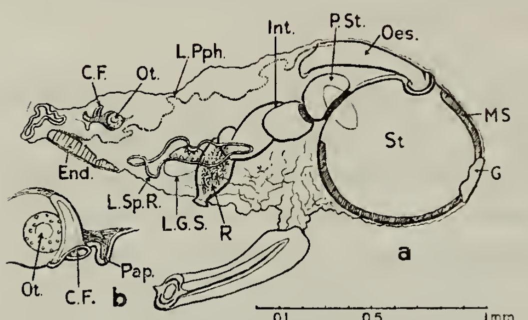

Fig. 5.—*Pelagopleura magna*, Lohm.

a, left-side view of the smallest specimen. The right peripharyngeal band and spiracular ring are omitted to avoid confusion. The former enters the œsophagus independently of the left band. Large flame-like cilia on the spiracular ring can be seen through the gaping external orifice of the gill-slit.

b, right-side view of the ciliated funnel and apparent otocyst on a larger scale. Brain and nerve-cord are not clearly distinguishable.

In this specimen, also in B but less clearly, the external apertures of the spiracles are recognisable as broadly oval apertures on each side of the anus and slightly in front of it, having about the same diameter as the rectum. The ciliated spiracular ring, with its much greater diameter, is seen on each side to be separated from the external aperture by a distinct interval, representing the delicate wall of the outer part of the gill-pouch. The endostyle is relatively as large as in B and again has nearly the same length and width as the rectum. The peripharyngeal bands leave the endostyle a short distance behind the front end and run obliquely backwards and upwards as independent structures until they are lost in the thickened wall of the œsophagus (cf. *Folia* above).

The German South Polar Expedition took this species on a single occasion during the drift of the "Gauss" in 63° 43′ S., but the subsequent Antarctic Expedition of 1911–12

took it at four different places in the Weddell Sea. The "Terra Nova's" specimens clearly support Lohmann's view that this species, like *O. valdiviæ*, is truly and exclusively Antarctic. It is noteworthy therefore that the "Terra Nova" failed to secure the other Antarctic species which Bückmann has distinguished as *P. australis*, and which the two German expeditions obtained on several occasions in the same regions as *P. magna*. The problem of *O. gaussica* is thus reinforced.

9. A remarkable specimen was taken at station 275 along with the two *Pelagopleuras* just described and a number of *O. valdiviæ*. Having a tail of about the same size and a flabby mutilated body not readily characterised, it was at first set aside as another *Pelagopleura*. The tail seemed to confirm this idea, for although of a type hitherto undescribed, it possessed two striking rows of amphichordal cells running the whole length of the tail, each row consisting of a continuous series of densely crowded small dark cells, which together confer upon it a bilineate appearance. These amphichordal cells are only known in two genera, *Pelagopleura* and the closely allied *Althoffia*, but no species of either genus has been described with continuous rows of them, though, as stated above, one of the "Terra Nova" specimens shows an approach to this condition. The body is torn to shreds and lacks any continuity between its parts, but the pharyngeal remnants include a pair of well-developed oblong and lobulated oral glands with a short oval endostyle (apparently broken) between them. As oral glands are absent from all these abnormal genera except *Stegosoma* and *Folia*, which possess subchordal, not amphichordal cells in their tails, we are compelled to report the specimen without any name at all. The combination of characters, few as they are, is unique and baffling.

The organs present in the mutilated body, apart from those mentioned, are (1) a short arched œsophagus connected with the pharyngeal remnants at one end but torn from its connection with the stomach which is missing, except for a few shreds; (2) fragments apparently of the right side of an intestinal knot; and (3) an anal papilla, firmly fixed in the thin tenacious remnants of the post-pharyngeal epithelium, but torn away from the rest of the rectum which, if present, is merely part of the mutilated tissues representing the right side of the gut already mentioned. The epithelial fins of the tail have almost entirely disappeared, so that the blastocœle gapes widely. It may be important to note that the amphichordal cells are here supported by a definitely gelatinous matrix, but for which they would almost certainly have disappeared as in one of our *Pelagopleuras*.

Postscript. During a recent visit to the Biological Station at Bermuda I have examined various specimens of *Stegosoma* that came up in the townettings. All conform to the type of *S. magnum*, and show no approach to the conical type of stomach of *S. conogaster*, thus confirming the distinctness of the Pacific species. An account of the Appendicularians of Bermuda, some of which are large forms of great interest, is in course of preparation. W. G. 30.iii.35.

KEY TO ABBREVIATIONS (except fig. 2).

An	Anus.
C	Cæcum.
CF	Ciliated Funnel.
End	Endostyle.
G	Gonads.
GS	Gill Slit (external aperture).
Ht	Heart (?).
Int	Intestine.
L	Left.
M	Mouth.
MS	Median Seam of large cells.
Oes	Œsophagus (with C = cardiac end).
OG	Oral gland.
Ot	Otolith (?).
Ov	Ovary.
Pap	Papilla.
Ph	Pharynx.
Pph	Peripharyngeal band.
P.St.	Post-stomach.
R.	Rectum (or Right).
SO	Suboral Oikothelium.
Sp.R.	Spiracular Ring of Cilia.
St.	Stomach.
T	Testis.
X	Torn edge of body-wall (omitted for clearness in fig. 1c).

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